GRADING & DRAINAGE

4

This chapter provides guidance for complying with specific federal, state, county, and city regulations applicable to floodplain management, water quality, and stormwater management within the city. It presents guidance for preparing drainage reports and grading and drainage plans using design standards and methodologies developed by the Flood Control District of Maricopa County.

Plan Review
7447 E Indian School Road
Suite 105
480-312-7080

One Stop Shop
7447 E Indian School Road
Suite 100
480-312-2500

Current Planning
7447 E Indian School Road
Suite 105
480-312-7000

Records
7447 E Indian School Road
Suite 105
480-312-2356

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GRADING & DRAINAGE 4

GENERAL INFORMATION 4.000

This chapter provides guidance for complying with various federal, state, county, and city regulations applicable to land development issues of floodplain management, water quality, and stormwater management. Examples of these regulations include the National Flood Insurance Act, the federal Clean Water Act (CWA), state and county statutes, and the Scottsdale Revised Code, specifically Chapter 37, otherwise known as the Floodplain and Stormwater Regulation (see www.scottsdaleaz.gov/codes). Other agency permits or certifications may be necessary to obtain prior to receiving permits from the city and those requirements, timeframes, and processes should be considered.

Specific guidance is presented for preparing drainage reports and grading and drainage plans using design standards and methodologies developed by the Flood Control District of Maricopa County (see www.fcd.maricopa.gov for the Drainage Design Manuals).

FEMA REQUIREMENTS 4.100

As a participant in the National Flood Insurance Program that is administered by the Federal Emergency Management Agency (FEMA), Scottsdale must require the following:

1. Lowest Floor Elevations shall be referenced to the city of Scottsdale's datum, NAVD 88. The nomenclature for referencing lowest floor elevations shall be LF88= "Elevation". If benchmarks or topographic information is not on this datum, then a datum equation shall be shown on the plans to equate the plan information to the city's datum.
2. All habitable structures must be designed such that they will not be flooded during any storm event up to and including the 100-year event, in accordance with Scottsdale Revised Code.
3. Construction documents that establish the lowest floor elevation for a habitable structure shall include a completed FEMA information block (see Section 1-2).
4. Habitable structures located in an area designated as a special flood hazard zone on the Flood Insurance Rate Map (FIRM) as mapped by FEMA must include an Engineer's Certification statement. This includes any zone other than B, C, D, or X zones.
5. A FEMA Finish Floor Certificate must be completed for all habitable structures, prior to the issuance of a Certificate of Occupancy (see Section 1-2).

SPECIAL FLOOD HAZARD ZONES 4.101

Portions of the city of Scottsdale fall within areas that have been designated special flood hazard areas, as mapped by FEMA. These special flood hazard zones are zone designations that begin with an "A", and require particular attention when being analyzed and designed for development. This includes alluvial fan flood hazard areas, which are designated by the symbol "AO" on the FIRMs.

Special requirements for developing on an alluvial fan must be followed. In general, there are two methods for developing on an alluvial fan—developing with, and developing without a map revision, as described below.

A. Developing Without a Map Revision

Developing without a map revision involves developing in the mapped AO Zone flood hazard area while leaving the FEMA designation unchanged. This method is a reasonable approach for low-density developments, small properties, and individual residences. It allows property development without the construction of major flood control measures. Although this method does not require approval from FEMA, it does require review and approval by the city for compliance with FEMA requirements. Since this method does not change the flood zone designation of the property, flood insurance requirements remain. Development requirements are listed below.

1. Proposed building sites (single family residence or subdivision) must be reasonably safe from runoff produced by the 100-year storm event.
2. Residential structures shall have the lowest floor (including basement or sunken room) elevated above the highest adjacent grade by at least as much as the depth number specified in feet on the FIRM. If no depth is specified on the FIRM, a minimum of two feet above the highest adjacent grade is required.
3. Site design and grading shall include adequate drainage paths around structures to guide floodwaters away from proposed structures. Structures shall not be placed in low spots or block active channels or flow paths on the fan.
4. The proposed development must address all potential flood hazard impacts created by the project within the flood hazard area (other areas of the fan), including adjacent and downstream areas beyond the mapped AO Zone.
5. Any property located below the apex of an alluvial fan, where the fan has not been structurally contained from the apex to said property, must protect its upstream perimeter with structural flood control measures. At a minimum, these measures must be designed to withstand the entire flow originating from the apex, plus tributary flows, based on existing watershed conditions, for the 100-year event. This methodology assumes runoff from the upstream watershed will not increase in the future.
6. Flow rates used to design perimeter flood control measures may be adjusted, as demonstrated by sound engineering analyses, if the actual flow rate reaching the perimeter is different from that at the apex. Specific city approval is required to utilize a flow rate less than the full apex flow.

B. Developing with a Map Revision - Removing Property from the AO Zone

Developing with a map revision involves removing the property from the AO Zone. Removal of a property from the AO Zone requires that a map revision of the FIRM be obtained from FEMA. The only basis for securing a map revision, according to FEMA, requires the construction of "major, structural, flood control measures." The design and construction of these measures must be supported by sound engineering methodology, and must demonstrate the effective elimination of the alluvial fan flood hazards, and must meet specific FEMA design requirements. Map revisions on alluvial fans, based only on fill, are not accepted by FEMA. Map revisions may require participation by multiple landowners. A property that has been removed from an AO Zone is not subject to flood insurance requirements unless specifically required by the lender.

1. Map Revision Requirements:

a. FEMA requires a thorough engineering analysis, which quantifies the peak discharge, volume of water, debris characteristics, and sediment loads produced by the runoff from a 100-year storm. This must be done at the alluvial fan apex under current and potential adverse (i.e., fully developed) watershed conditions. It must

be shown that the proposed flood control measures will effectively eliminate alluvial fan flood hazards from the fan area.

b. The minimum FEMA freeboard requirement for flood control structures on an alluvial fan is three to four feet, depending on the proximity to bridges, etc. A lesser freeboard may be possible; however, FEMA does not accept a freeboard of less than two feet. The city requires that the engineering analysis demonstrate adequate freeboard and meet FEMA requirements.

c. FEMA requires that the city of Scottsdale assume ultimate responsibility for all operation and maintenance activities for major, structural, flood control measures. Responsibility for operation and maintenance activities is generally delegated to homeowners associations or other private property owners or associations. Other methods, such as contracting through the Flood Control District of Maricopa County (FCDMC), require legal agreements adopted by City Council.

d. The proposed development must address all potential flood hazard impacts created by the project within the flood hazard area (other areas of the fan), including adjacent and downstream areas beyond the mapped AO Zone.

SECTION 404 PERMITS 4.200

Scottsdale is a participant in the National Flood Insurance Program. The Code of Federal Regulations requires that if a community chooses to participate in the National Flood Insurance Program, it must assure that developments within its boundaries comply with Section 404 of the federal Clean Water Act (CWA).

REGULATED ACTIVITIES 4.201

The US Army Corps of Engineers (Corps) and the US Environmental Protection Agency jointly administer Section 404 of the CWA. The CWA regulates the discharge of dredged or fill material into washes, rivers, streams, lakes, certain man-made canals, and other waters of the United States, including wetlands. Examples of activities that might be regulated under this program include:

- Stream crossings
- Dam construction and flow regulation
- Water diversion for canals, irrigation systems, and stock tanks
- Streambed modification and stabilization, and
- Building subdivisions, master planned communities, highways, and airports.

In addition, the US Fish and Wildlife Service, Arizona Department of Environmental Quality (ADEQ), Arizona Game & Fish Department, and Arizona Department of Water Resources have important advisory roles. In order to allow time for permit processing and coordinating with their timeframes, contact the Corps early in the project planning stage for information about permits and submittal and notification requirements. See http://www.spl.usace.army.mil/ and click on Regulatory, then Permit Process within Arizona State, for specific information.

Individual permits may be required for projects with potentially significant impacts and require public notice. Nationwide permits (currently 44 activity-specific permits) may be authorized for activities with minimal environmental impact and undergo a streamlined process.

Section 404 permit activities may not jeopardize the continued existence of a threatened or endangered species or its critical habitat. Consult with the Corps or the US Fish and Wildlife Service for guidance concerning the Cactus Ferruginous Pygmy Owl and other threatened and endangered species within Scottsdale.

4.202 COMPLIANCE REQUIREMENTS

Applicants must complete the city of Scottsdale Section 404 Certification Form as assurance that a development project complies with Section 404 of the CWA. See www.scottsdaleaz.gov/design/dspm/forms for this form.

An applicant must submit a completed form with improvement plans to Project Review staff prior to receiving any development permits. In order to prevent delays in obtaining development permits, developers should apply to the Corps for a Section 404 permit as early as possible and allow for the necessary processing time.

4.203 SECTION 401 CERTIFICATION

While the Corps issues the Section 404 permit, Section 401of the CWA requires ADEQ to certify, possibly with additional permit conditions, that the draft permit complies with effluent limits, state water quality standards, and any other appropriate requirements of state law. The goal of the program is that no discharge of dredged or fill material will be permitted if either a practicable alternative exists that is less damaging to the aquatic environment, or, if the nation's waters would be significantly degraded.

ADEQ has authority under Section 401 of the CWA to grant, deny, or waive water quality certification for both individual and nationwide Section 404 permits. The Corps cannot issue a permit, individual or general, where ADEQ hasn't approved or waived certification or where ADEQ has denied certification. For more information, contact ADEQ or visit www.azdeq.gov/environ/water/permits/dredge.html.

4.300 STORMWATER QUALITY

4.301 CONSTRUCTION GENERAL PERMIT

Before any construction activities that will disturb 1 or more acres begin, these activities must be authorized by ADEQ under the Arizona Pollutant Discharge Elimination System (AZPDES) Construction General Permit. The city also requires evidence of compliance before issuing development permits.

Stormwater runoff from construction sites can include pollutants such as phosphorous and nitrogen, pesticides, petroleum derivatives, construction chemicals, solid wastes, and sediment that adversely affect water quality. Compliance under this general permit will help prevent these pollutants from entering washes, lakes, and other surface waters and the city's storm drain system.

4.302 HOW TO OBTAIN COVERAGE

The operator of a construction site is responsible for obtaining coverage from ADEQ under the AZPDES permit. The operator can be the owner, developer, general contractor, or individual contractor responsible for operational control. When this responsibility is shared, all operators must apply for coverage.

To gain coverage, operators of construction sites must:

- Submit a Notice of Intent (NOI) to ADEQ for authorization;
- Prepare and implement a Stormwater Pollution Prevention Plan (SWPPP) and keep a copy on site;
- Include 2 copies of the NOI and SWPPP with the improvement plan submittal to the city;
- Send a Notice of Termination (NOT) to ADEQ and the city once construction is completed, as defined in the general permit.

Contact ADEQ at (602) 771-4449 for specific permit requirements or see their website www.azdeq.gov/environ/water/permits/stormwater.html#const for NOI and NOT forms and guidance for preparing the SWPPP. Forms are also available from the city's One Stop Shop.

STORMWATER MANAGEMENT 4.400

METHODOLOGY 4.401

Scottsdale utilizes the designs standards and methodologies, except where noted, of the Flood Control District of Maricopa County, as described in their Drainage Design Manuals that include Volume I Hydrology, Volume II Hydraulics, and Volume III Erosion. The manuals may be obtained from the Flood Control District or from their website, www.fcd.maricopa.gov. Scottsdale standards and policies shall prevail for any discrepancy between the Flood Control District's manuals and city design standards ad policies . Engineers should discuss any such discrepancy with the appropriate city staff for resolution prior to submitting reports and plans for review.

The city's stormwater storage requirements are contained in Chapter 37-42(l), "Floodplain and Stormwater Regulation" of the Scottsdale Revised Code (see www.scottsdaleaz.gov/codes).

STORMWATER STORAGE 4.402

Stormwater storage facilities will be designed as detention facilities. Retention facilities are a rarely acceptable alternative and will only be allowed with prior written consent from city staff.

The use of drywells is generally prohibited, and requires express written consent from the city of Scottsdale. All other alternatives for managing the disposal of stormwater shall be investigated prior to consideration of the use of drywells.

A. Stormwater Storage Basin Design

1. Design Volume

City Code requires that "As a minimum, all development will make provisions to store runoff from rainfall events up to and including the one-hundred-year two-hour duration event." This storage requirement applies to the total disturbed area within the development to the centerline of adjacent streets and alleys, and includes all easements, tracts, and other rights-of-way. The disturbed area includes any man-made change, such as, but not limited to construction, mining, excavation, filling, grading, or paving. The volume of storage provided onsite must equal the total runoff volume generated from all the disturbed area within the site for fully developed conditions. Pre-development versus post development comparisons are not applicable in computing required storage volumes.

The storage requirement is not applicable to undisturbed, natural areas and such areas on a site may be excluded from the area used in the storage requirement calculation.

2. Certified Volume

The property owner will provide the city with certified as-built dimensions of the basins and the actual volume of storage provided. This must be based on "as-built" topographic surveys performed by an Engineer or Land Surveyor licensed in the state of Arizona. These as-built volumes must reflect permanent, finished landscaping in place. The "as-built" volume must meet or exceed the required design volume. A Letter of Certification prepared by an Engineer licensed in the State of Arizona, must be submitted to the city, stating that the provided volume meets or exceeds the required design volume, and that the facility is

constructed to perform as designed. The volume of storage provided must equal or exceed the approved design volume before the city will issue a Letter of Acceptance.

B. Storage Facilities

1. Offsite washes should not be routed into or through onsite stormwater storage basins. Basins located on-stream interrupt the natural flow regime of the wash and can create a continual debris and sediment maintenance problem.
2. Storage basins should be designed with a positive gravity drain system whenever possible. City Code Section 37-42 (l)(3) identifies other acceptable methods of draining (see www.scottsdaleaz.gov/codes). Dry wells may only be used as a last resort.
3. Basin side slopes shall not exceed a 4:1 (4 foot horizontal to 1 foot vertical) ratio.
4. The depth of water in a basin shall not exceed 3 feet, as calculated using the volume from the 100-year storm event.
5. Storage basins shall have an emergency spillway to safely direct any overflow into a recognized watercourse.
6. Above ground storage basins contained by an earthen dam or levee are prohibited unless the fill is part of an approved street or road design.
7. Storage facilities on individual residential lots are generally prohibited and only allowed in specific circumstances that must be approved in advance by city staff.
8. On-lot storage is only permitted when unobstructed physical, legal, and visual access are provided.
9. A drainage easement contiguous to public right-of-way shall be dedicated such that it provides legal access to, and fully encompasses the physical limits of the basin for the purpose of inspecting, maintaining, or reconstructing the basin in the event the owner fails to do so.
10. Storage water shall be designed to drain to a recognized watercourse. Water may not generally be discharged onto a city street, gutter or alley. Specific, prior written approval from the city is required to discharge water into a street, alley, or gutter.
11. All storage facilities shall be designed such that the stored runoff shall be discharged completely from the facility within 36 hours following the storm event. This city ordinance requirement is related to Maricopa County Health Department Standards.
12. Drain time should be maximized to ensure the effectiveness of the basin. Drain time should generally be from 12 hours to 24 hours. Discharge from the basin may be regulated with an orifice plate over the entrance of the outlet pipe, as long as the outlet pipe meets the minimum size pipe requirements.

4.403 STREET DRAINAGE

A. 100-Year Access

All properties, as a condition of development, must be accessible during the 100-year frequency storm event. Access is considered to exist if it is demonstrated that at least one access road, consisting of a structural roadway section such as asphalt, concrete, or compacted aggregate, has a depth of flow no greater than 1 foot during the peak flow for the 100-year frequency event. See Figure 4-2 for allowable limits of inundation for specific street sections.

B. Valley Gutters

Valley gutters are permitted on local streets for the purpose of transporting runoff when a storm drain system is not required. Valley gutters are generally not acceptable for use on collector or arterial streets. In unusual cases, valley gutters may be necessary in order to

convey runoff across a collector street. In such situations, the valley gutter shall be a minimum of 8 feet in width in order to lessen the impact on traffic.

C. Roadside Ditches

Ditches must intercept and safely convey flow to the nearest recognized watercourse. If more than normal sheet flow runoff from the road cross section or cut slope is intercepted or accumulated in the roadside ditches before it can be safely discharged, then the ditches need to actually be sized. If velocities exceed 4 to 5 feet per second, then appropriate erosion or scour protection must be provided. Ditches are necessary to prevent runoff and debris from washing onto the roadway and causing erosion of roadway areas adjacent to the edge of pavement or curbing, and prevent roadway runoff from flowing into front yards, driveways, garages, and homes.

See Figure 4-1 for a typical cross section for roadside ditches for use on non-raised curb street or straight cross slope.

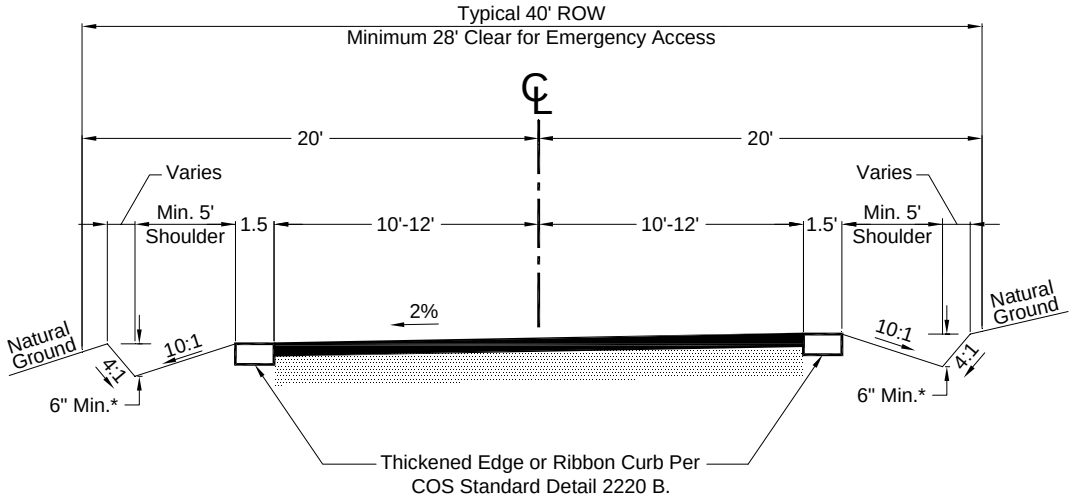


FIGURE 4-1. TYPICAL CROSS SECTION FOR ROADSIDE DITCHES

CHANNEL DRAINAGE 4.404

A. Channel Lining

The design flow capacity of a wash or channel may not be reduced by the placement of channel lining or erosion protection, or landscaping material, including revegetation. Channel sections shall be designed such that the final finish grade is the surface of any channel lining or erosion protection, and channel flow capacity shall be calculated with appropriate reductions for any landscaping or revegetation within the limits of inundation for the 100-year event.

B. Culvert Sizing

1. The minimum pipe size of culverts and storm drain laterals shall be 18 inches in diameter. In situation where debris may be expected, the consult with City staff for applicable debris criteria.

HYDRAULIC DESIGN CRITERIA *(Italics indicate citations from Floodplain and Stormwater Regulation)*			
Drainage Feature	**Peak Frequencies**		
	10 Year	**50 Year**	**100 Year**
Street with Curb & Gutter	Contain runoff within street curbs. For collector and arterial streets maintain one 12-foot dry driving lane in each direction.	N/A	Contain runoff below the building's finished floor. *Runoff to be confined to road right of way or to drainage easements.*[37-42, (4)] *dmax=8 inches above the street.* [37-42, (4)]
Street without Curb & Gutter (Dirt Roads, Ribbon Curbs)	Contain runoff within roadside channels with water surface elevation below roadway pavement's subgrade.	N/A	Same as Street with Curb and Gutter.
Street with Storm Drain System	Add pipes or roadside channels if 10-year runoff exceeds street capacity.	N/A	Use storm drain systems if 100-year runoff inundates building's first floor. *Catch basins, scuppers, etc. to be provided to remove water so as not to exceed dmax =8".* [37-42, (4)]
Cross Road Culvert or Bridge for Major Collector & Arterial Streets	N/A	*Runoff to be conveyed by culvert or bridge under road with no flow overtopping the road*. [37-42, (3) a. 2]	*Runoff to be conveyed by culvert and by flow over the road with maximum 6-inch flow depth over the road.* [37-42, (3) a. 2]
Cross Road Culvert or Bridge for Local and Minor Collector Streets	*Runoff to be conveyed by culvert or bridge under road with no flow overtopping the road.* [37-42, (3)a.1]	*For a 25-year frequency storm runoff to be conveyed by culvert or bridge and by flow over the road with maximum 6-inch flow depth over the road.* [37-42, (3) a.1]	Maximum depth over road 12 inches.
Any street or watercourse crossing that provides the only access to residential area.	N/A	N/A	*All lots and structures must be accessible by at least one route with the depth of flow no greater than one foot during the 100-year runoff event*. [37-42, (3) a. 3]
FEMA Floodplain Channel (1)	N/A	N/A	100-year peak discharge
Open Channel for Offsite Flow through Development	N/A	N/A	100-year peak discharge
Detention / Retention Storage Basin	N/A	N/A	100-year 2-hour storm for determining on-site retention volume

FIGURE 4-2. HYDRAULIC DESIGN CRITERIA

2. Private culverts should be sized to manage the 100-year runoff, but should not be less than 15 inches in diameter when possible. Culvert installations that do not have 100-year peak flow capacity must be designed to adequately convey the balance of runoff by channel or other means to the appropriate watercourse.
3. If a culvert invert is placed more than 0.5 feet below the natural wash flowline, the capacity of the culvert must be reduced by the cross sectional area below this depth.

MULTIPLE FREQUENCY EVENTS 4.405

Stormwater runoff shall be managed for all storm events. This includes management and peak attenuation of minor storm events in addition to the 100-year event. Runoff from events greater than the 100-year event must be directed to recognized watercourses and away from structures. See Figure 4-2.

50 CFS WASHES WITHIN ESL AREAS 4.406

The Environmentally Sensitive Lands Ordinance (ESLO) directly impacts the location and design of residential, commercial, industrial, and institutional development in two-thirds of the city. It identifies and protects environmentally sensitive lands (ESL) and promotes public health and safety by controlling development on these lands. The ordinance requires that a percentage of each property be permanently preserved as natural area open space (NAOS) and that specific environmental features, including vegetation, washes, mountain ridges and peaks, be protected from inappropriate development. The City Council adopted changes to ESLO, effective in May 2004, that defined natural washes as the highest priority for dedicating NAOS and created a review process for modifying significant washes. See Section 2-2 and www.scottsdaleaz.gov/codes for ESLO requirements.

A. Protecting 50cfs Washes

With the 2004 ESLO revision, natural wash preservation became the highest priority for site plan development. Site plan designs should accommodate natural washes in their native locations and conditions. The goal is to minimize modifications of the flow and natural features of significant washes.

Significant washes are defined as having a 100-year storm flow of 50 cubic feet per second (cfs) or more. Washes of this type typically have concentrations of mature and dense vegetation along their banks. In some cases it will be necessary to modify the existing character of a wash to accommodate reasonable improvement of a property and protect lives and property. Applicants must submit an ESLO Wash Modification Form when proposing to alter a wash of 50 cfs or greater flow. The modification may be granted by the Zoning Administrator if both the drainage facilities design solution is approved and the purpose of the ESL overlay district is achieved. Note that the city cannot require dedication of more NAOS than is currently required by this ordinance. For the ESLO Wash Modification Form see www.scottsdaleaz.gov/design/dspm/forms.

Walls are not allowed to cross major or minor washes, as defined in ESLO, unless specifically approved by the City Council. Wash corridors should provide for unimpeded flows of stormwater and the movement of native wildlife.

B. ESL Resources

Maps showing the locations of known washes, steep slopes, boulder formations, and existing NAOS areas are available as resources to assure reasonable continuity of natural areas and protection of more significant and sensitive natural features. Maps are available at the ESLO web site: www.scottsdaleaz.gov/codes and select ESLO & NAOS Maps.

The goal of the ESL Ordinance is to leave washes in place and in natural conditions where it is practical to do so. When necessary, modifications to natural watercourses and all walls and fences crossing natural watercourses will be designed in accordance with the standards and policies specified in Chapter 37 of the Scottsdale Revised Code - Floodplain and Stormwater regulation, and guidance from this manual (see Section 2-2).

Wash Modifications will only be granted if the applicant complies with all the following:

- Proposed modifications result in an equal or enhanced quality of open space, and
- Modification of a watercourse must include restoration of the watercourse with vegetation of the same type and of the same density as existed prior to the modification, and
- If the wash being redirected or otherwise modified, the wash must enter and exit the site at the historic locations, and the result of the modifications shall not impact drainage considerations for adjacent properties, and
- If the wash is being diverted into a structural solution (e.g. underground pipe), the change must not impact the drainage conditions on adjacent properties and shall not reduce the integrity of any upstream or downstream corridor as meaningful open space, and
- Applications must include a description of alternative watercourse management and engineering techniques considered for the site.

4.500 STORMWATER WAIVERS

4.501 WAIVER OF STORMWATER STORAGE REQUIREMENTS

In accordance with the Floodplain and Drainage Ordinance, stormwater storage requirements may be waived if a project meets one or more of the specific criteria listed in the Code. Meeting the waiver criteria does not mean a waiver will automatically be granted. The potential for cumulative effects must be considered, and must also be in the best interest of the public.

4.502 WAIVER REQUIREMENTS

1. All onsite storage requirements may be waived if a site can drain directly into an existing regional drainage system designed and constructed to contain or convey the additional runoff; however, a more common occurrence is that a development must, as a minimum, store the runoff volume necessary to maintain pre-development flow conditions.
2. A waiver approval of any kind is not authorization by the city for the developer to increase runoff or change drainage characteristics to the detriment of any other property owner.
3. A waiver approval does not relieve the developer of liability if the project causes increased flood damage on any other property.

4.503 WAIVER PROCESS

To obtain a waiver, the developer must submit for review a Request for Stormwater Storage Waiver Form with completed In-Lieu Fee Calculations Sheet. After staff's review is complete, the applicant will receive a copy of the processed Waiver Form, which will indicate: additional information needed, approval, or denial of the request.

Final improvement plans will not be accepted for review without a copy of the approved Waiver Form, unless the project is designed to provide the full ordinance storage volume.

The completed Waiver Form, including the In-Lieu Fee Calculations sheet, must be included in the final drainage report when submitted for city approval; they can be downloaded from www.scottsdaleaz.gov/design/dpsm/forms.

IN-LIEU FEES 4.504

To obtain a stormwater storage waiver, the Drainage Ordinance requires the development to contribute to the cost of drainage works. In-lieu contributions will be applied to the construction of drainage improvements throughout the city. The developer shall calculate the in-lieu contribution based on the greater of the pro-rata cost to improve downstream drainage facilities or fair market value of the land area that would otherwise be required to construct the drainage storage facilities. The In-Lieu Fee Calculations Sheet must be included with the Request for Stormwater Storage Waiver Form when submitted to the city for review and approval. See www.scottsdaleaz.gov/design/dpsm/forms.

DRAINAGE EASEMENTS 4.600

EASEMENT DEDICATION 4.601

A. Conditions Requiring Dedication of Drainage Easement

In accordance with the Floodplain and Drainage Ordinance, drainage easements are required for all natural and man-made drainage ways with a 100-year, 2-hour peak flow of 50 cfs or greater in ESL areas, and for all natural and man-made drainage ways with a 100-year, 2-hour peak flow of 25 cfs or greater in non-ESL areas. In addition, all drainage facilities, including structures and storage basins, must be incorporated into a drainage easement. Easement dedication and confirmation forms are available at www.scottsdaleaz.gov/design/dspm/forms.

B. Extent of Drainage Easement Dedication

A Drainage Easement shall be dedicated to the limits of inundation of stormwater from the 100-year 2-hour storm event for all natural and man-made drainage ways described above, including structures and storage basins. Drainage Easement dedications shall encompass all physical structures, including sufficient area to access and maintain the drainage facility. Drainage Easements shall either be contiguous to roadway rights-of-way, or an additional easement for the purposes of access, inspection, and maintenance of the basin shall be dedicated to the city of Scottsdale, regardless of maintenance responsibilities for the basin or facility.

RELEASE OF DRAINAGE EASEMENT 4.602

A. Requirements for Releasing a Drainage Easement

Release, including modification, of an existing drainage easement is possible only if one of the following circumstances can be documented:

- Upstream flows have been physically cutoff or diminished;
- More detailed or accurate topographic mapping and/or aerial photography show the original dedication to be incorrectly located; or,
- The original hydrology is outdated or in error.

B. Release of Easement Process

The Application to Release Existing Drainage Easement Form must be completed, along with a comprehensive drainage report that justifies the release as described above. See www.scottsdaleaz.gov/design/dspm/forms.

4.700 DRAINAGE REPORTS

The purpose of this section is to outline the requirements for and provide guidance in the preparation of Drainage Reports for submittal to the city. See Appendix 4-A for a Sample Outline for Drainage Reports.

This section is based on recommended procedures, data, and basic assumptions used by engineers or designers, including but not limited to: publications of the Flood Control District of Maricopa County as referenced in Section 4-501; other sections of this manual; and regulatory requirements. If additional or alternative methods or data are believed more appropriate, then city staff should be consulted, and prior approval received before proceeding. When methods or data not described in this booklet are used, the drainage report must include enough information to enable the city staff to fully evaluate the applicability of the methods and data. If a computer program is used that the city does not have in its software library, the consultant must provide the city with a fully usable copy of the appropriate software, or show adequate comparisons with known procedures. See Appendix 4-A for a Sample Outline for Drainage Reports.

4.701 GOALS AND OBJECTIVES

At a minimum, drainage reports should meet the following basic goals and objectives:

- Reflect requirements of the city floodplain and drainage ordinance, and other applicable county, state and federal regulations
- Use the best and most current data available
- Provide safe, reasonable, and reliable results
- Are not unnecessarily complex or confusing
- Provide results that are consistent with adjacent jurisdictions
- Are technically and legally defensible

4.702 ACTIVITIES REQUIRING A DRAINAGE REPORT

An applicant is required to submit a drainage report when requesting one or more of the following:

- General Plan Amendment or re-zoning
- Subdivision plat approval (preliminary and final)
- Development Review Board case approval
- Permit to construct right-of-way improvements
- Permit to construct any structure.
  A drainage report is not needed if the structure is a single family residential structure without a basement in Flood Hazard Zones B, C, D, or X, and is not located in the vicinity of a watercourse where the flow of rainfall runoff might be hazardous to the structure or its occupants, as determined by the city.
- Grading permit, unless the Floodplain Administrator waives the requirement
- Modification or release of a dedicated drainage easement
- Lot split.

APPLICATION AND LIMITATIONS 4.703

The city does not warrant or guarantee the reliability of the hydrologic methods, techniques, and/or parameter values described herein. The user of this manual is expected to validate the reasonableness of the estimated values by applying alternative methods or other appropriate means. See Appendix 4-B Warning and Disclaimer of Liability.

It is not the intent, nor purpose, of this manual to inhibit sound innovative design or the use of new techniques. Therefore, where special conditions or needs exist, other methods and procedures may be used with prior city approval and appropriate documentation to support the validity of the methods.

DRAINAGE REPORT PREPARATION 4.704

A. Requirements for a Drainage Report

A drainage report must:

- Analyze existing and proposed conditions, and document the effect that a proposed project would have upon stormwater runoff;
- Provide data to insure that the project will be safe from flooding;
- Provide data supporting the design of drainage and flood control facilities.

Each drainage report must consider runoff from storms with a return frequency **up to and including** the 100-year event. Storm events more frequent than the 100-year event must be managed in addition to the 100-year event. Development shall not increase peak discharge rates above the historic peak discharge rate for any frequency event up to and including the 100-year event. The complexity of the report depends upon the nature of the project and the site on which the project will occur.

A drainage report shall be prepared by, or under the direct supervision of, an Engineer licensed to practice in the State of Arizona, and shall bear the seal, signature, and date as required by the Arizona State Board of Technical Registration. The drainage report, related design, and improvement plans must conform to the requirements of the city's current Floodplain and Stormwater Ordinance, applicable sections of this manual, and other county, state and federal regulations.

B. The Purpose of a Drainage Report

The purpose of a drainage report is to document that stormwater runoff has been considered in the planning of a project, and that the public and its property will be protected from damage by runoff and flooding to the extent of the 100-year flood event. This applies to all properties adjacent to, or potentially impacted by, a development in addition to the property to be developed.

C. Elements of a Drainage Report

Each drainage report shall include a detailed narrative, topographic maps, and aerial photographs that describe the location and condition of the property to be developed (on-site), upstream watersheds, and downstream conditions and/or constraints that affect the property. Refer to Appendix 4-A, “Outline for Drainage Reports”, for specific items to be included (as applicable) in all drainage report types, including a master drainage plan. See Appendix 4-B for a checklist of Master Drainage Plan submittal requirements.

D. On-Site Conditions

This section of the report should include the following basic information about the property, as applicable:

1. Narrative description of existing drainage patterns, natural and constructed watercourses, open channels, storm drains, storage basins, and any other drainage

structures or improvements; and a map depicting the existing conditions, including all of the aforementioned items, plus the 100-year floodplain for all washes with either a capacity or 100-year flow rate of 25 cfs or greater, or if in ESL areas, 50 cfs or greater.

2. Description of the existing ground cover conditions and how the identification of the SCS hydrologic soil group(s) or appropriate Green-Ampt soil characteristics were identified for the property. Provide the SCS soil mapping excerpts.
3. Description of any existing development located on the property and how it affects drainage.

E. Off-Site Watershed Conditions

Watersheds from which stormwater enters or affects the property to be developed must be delineated on topographic maps. These maps should be prepared at a scale that clearly identifies drainage areas such that watershed boundaries can be accurately drawn. Contour lines shall be shown on the maps, the interval of which should be appropriate for the slope and complexity of the terrain. Recent aerial photographs are available at Digital Map Center (www.scottsdaleaz.gov/dmc) or from the city's Records Department. Current aerial photograph(s) that show the off-site watershed areas and adjacent properties, relative to the project site, must be included in each drainage report.

This section of the report should include the following basic information, as applicable:

1. Existing upstream and downstream drainage patterns and a description of how existing developments on adjacent properties affect drainage on the project area;
2. A description of the ground cover conditions assumed and how the SCS hydrologic soil group(s) or Green Ampt soil classes were determined for the offsite watersheds;
3. A description of fully developed offsite conditions in accordance with the approved Land Use Element of the General Plan for Scottsdale, with a discussion of any potential adverse affects on this, or other projects.
4. A description of any proposed projects or developments, that have approved designs, that will affect this property. Research approved drainage plans and reports for private or capital improvement projects that may impact drainage on the property.
5. Describe any other unusual conditions, which would significantly affect drainage on the property.

F. Proposed Drainage Plan

Describe how the proposed project will manage stormwater runoff and the sequence of infrastructure installation and any planned phasing of the project.

1. Depicting pre- and post-project topography

Prior to development, existing topographic conditions influence the flows of stormwater runoff from off-site watersheds as well as runoff originating on the property. Topographic changes resulting from development will impact these drainage characteristics, including the time of concentration. The drainage report must include sufficient pre- and post-project topographic information to demonstrate these impacts. This information shall be depicted on contour maps that show adjacent properties, including off-site watersheds, in addition to the property being developed, to provide context for the potential impact of development. Information about adjacent property, such as significant differences in elevation, walls, drainage structures, buildings (including lowest floor elevations), etc. must be included.

2. Pre- and Post-Project Stormwater Runoff

The amount and characteristics of the stormwater runoff exiting the property both prior to and after development shall be depicted for the 2-year, 10-year, and 100-year storm events. If, as a result of development, drainage flows will be reduced by facilities such as stormwater storage basins, the effect of these facilities on flows exiting the property should be described and depicted on appropriate maps. Construction of roads, parking

areas, roofs, channels, and other development features results in the increase of runoff volumes, peak discharge rate, and reduces times of concentration.

3. **Basis of Design for Drainage and Flood Control Facilities**

   Summarize the design criteria used; provide a description of the facility, its purpose, and the design approach used. Details, sketches, data, and calculations that support the design and the criteria for the selection of materials and the location should be included in an appendix.

4. **Basis for Selection of Lowest Floor Elevations**

   Lowest floor elevations must provide protection from flooding. The basis for the selection of a floor elevation, or the design of protection for the interior of the building, must be clearly presented. Supporting documentation should be included in an appendix.

G. Conclusions

1. **Overall Project**
   Conclusions based on the completion of the project in its entirety; applicable to projects that are not constructed in phases, or upon the completion of all phases within a project.

2. **Description of the Provisions for Project Phasing**
   The phasing of parcels and the timing of the installation of drainage facilities should be described. Any project, particularly a large one, may have interim stormwater runoff, flooding, and erosion problems that would not exist after project completion. The report must indicate how the phasing will occur, what interim drainage problems are anticipated, and what interim measures will be taken to protect against them.

MASTER DRAINAGE PLAN REQUIREMENTS 4.705

Appendix 4-B is provided as a checklist to assist in submitting a complete and successful Master Drainage Plan to the city. The items on this list are required as part of the submittal of a Master Drainage Plan in addition to the requirements of Section 4.704. Submittals shall include 2 copies of the Master Drainage Plan Report for the initial and subsequent reviews, 6 copies for final approval.

METHODS FOR ESTIMATING PEAK DISCHARGE 4.706

Two methods are defined for the determination of peak discharges: the Rational Method, and rainfall-runoff modeling using the U.S. Army Corps of Engineers' HEC-1 Flood Hydrograph Package. For watersheds less than 160 acres, the Rational Method is acceptable. For watersheds that are non-uniform, irregular in shape, or larger than 160 acres, or if routing of flows is necessary, HEC-1 modeling is required. Prior approval by city Staff is required for the use of other methods.

A. Watershed Conditions

Watershed conditions that produce the greatest peak flow rate shall be used to size drainage facilities or to determine lowest floor elevations of a structure to protect from flooding. A watershed that is fully developed in accordance with the city's General Plan Land Use Element will usually produce the greatest peak flow rate, but other interim conditions such as the current state or development of the watershed in accordance with existing zoning may produce a greater peak flow rate and must be considered.

B. Split-Flow Conditions

Split-flow channel conditions exist in northern parts of Scottsdale, and must be taken into consideration. These splits in the alluvial channels usually include highly erosive soils and

are generally unstable, and therefore unpredictable. In setting finished floor elevations relative to upstream splits, it should be assumed that 100% of the flow could go either direction in any given flood event. For infrastructure design, the estimate of the actual split based on a hydraulic analysis of the current channel cross sections must include a minimum safety factor of 30 percent of the total flow. If the designer feels that there are extenuating factors affecting the stability of the split, the safety factor should be increased accordingly. The report should include a description of all assumptions made regarding watershed conditions used to calculate the peak flow rates.

C. The Rational Method

The Rational Method is limited to use on small, uniform, regularly shaped watersheds less than or equal to 160 acres in size. The methodology is provided in the FCDMC Hydrology Manual. Calculations shall be submitted using Figure 4-3, or a similar form containing the same data and information. Frequency adjustment factors are included in this figure.

HYDROLOGIC DESIGN DATA RECORD - RATIONAL METHOD

Project: _____ Concentration Point: _____

Location: _____

Project No.: _____ Station: _____

Name of Stream/Watershed: _____

Design Data:

		Design Frequency						
		2	5	10	25	50	100	Year
Drainage Area	**A1**							
	A2							Acres
	A3							Acres
	Total (A)							Acres
Drainage Length								Feet
Elevation								
Top of Drainage Area								Feet
At Structure								Feet
Drainage Area Slope								%
Hydrologic Soil Group								

Design Computations:

		Design Frequency						
		2	5	10	25	50	100	Year
Time of Concentration	T_C							
Rainfall Intensity (I) *(see Figure 4-4)*								inch/hr
Runoff Coefficient (C)	**C1**							
	C2							
	C3							
Weighted Runoff Coefficient (C_W)	C_W							
Peak Discharge $Q_P = C_W IA(F)$								cfs

Computed by: _____ Date: _____

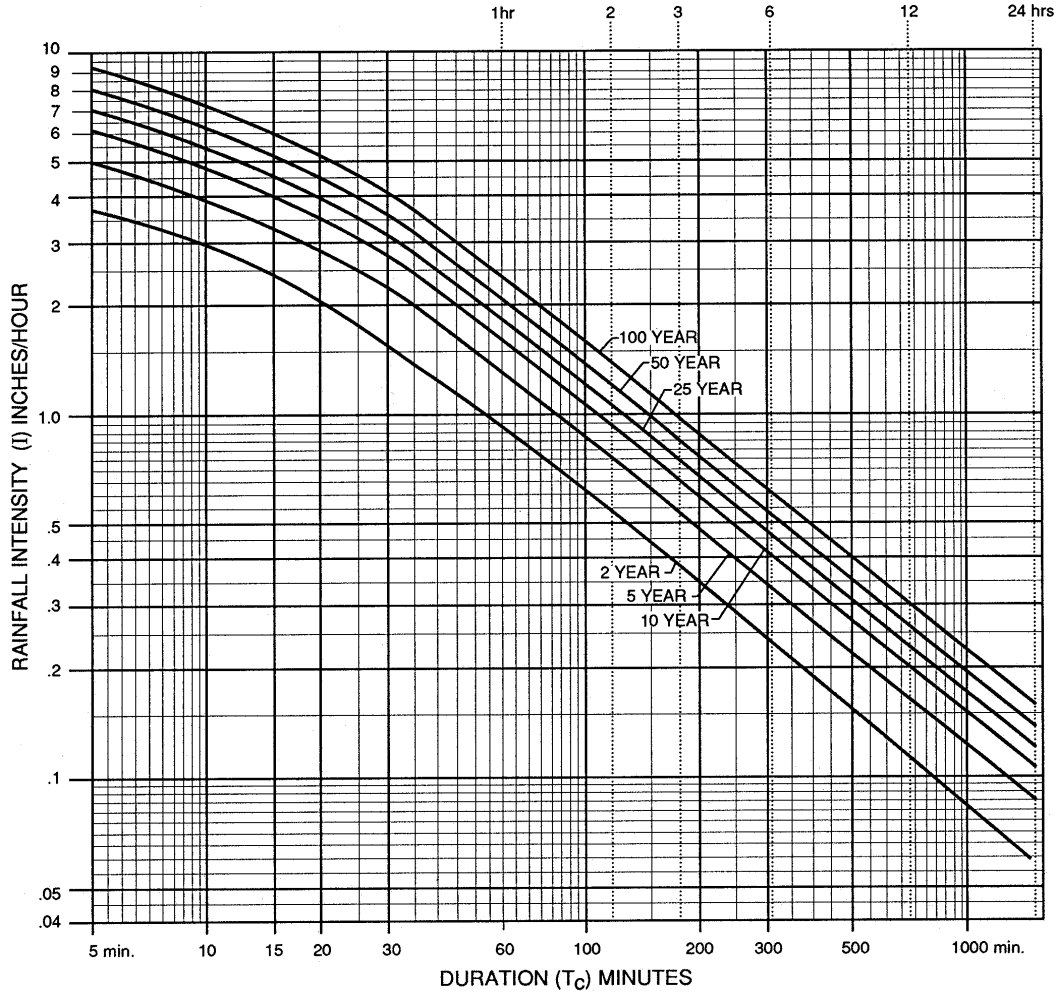
Checked by: _____ Date: _____

1. Runoff coefficients for 25-, 50-, and 100-year storm frequencies were derived using adjustment factors of 1.10, 1.20, and 1.25, respectively, applied to the 2-10 year values with an upper limit of 0.95.
2. The ranges of runoff coefficients shown for urban land uses were derived from lot coverage standards specified in the zoning ordinances for Maricopa County.
3. Runoff coefficients for urban land uses are for lot coverage only and do not include the adjacent street and right-of-way, or alleys.

FIGURE 4-3. HYDROLOGIC DESIGN DATA RECORD—RATIONAL METHOD

1. Precipitation

Precipitation input is rainfall intensity, "**I**," obtained directly from Figure 4-4, which applies citywide. The time of concentration, "**Tc**," is all that is required to determine "**I**" from this figure.



(source: Hydrologic Design Manual for Maricopa County)

FIGURE 4-4. RAINFALL INTENSITY (I) VALUES FOR USE IN RATIONAL METHOD

2. Time of Concentration

Time of concentration, "**Tc**", is the total time of travel from the most hydraulically remote part of the watershed to the concentration point of interest.

Do not add a standard set amount of time to the estimated "Tc" for lot runoff delay (such as 5 or 10 minutes). Natural land slopes are too variable in Scottsdale to add a set amount of time for lot runoff.

3. Runoff Coefficients

Use Figure 4-5 or equivalent to obtain the runoff coefficients, or "**C**" values. Composite "**C**" values for the appropriate zoning category or weighted average values calculated for the specific site, are both acceptable approaches.

RUNOFF COEFFICIENTS - "C" VALUE			
LAND USE Composite Area-wide Values	**Hydrologic Soil Group**		
	B	**C**	**D**
Commercial & Industrial Areas	0.90		
Residential Areas-Single Family (av. lot size)			
R1-1-1901	0.33	0.50	0.58
R1-130	0.35	0.51	0.59
R1-70	0.37	0.52	0.60
R1-43	0.38	0.55	0.61
R1-35 (35,000 sq. ft./lot)	0.40	0.56	0.62
R1-18 (18,000 sq. ft./lot)	0.43	0.58	0.64
R1-10 (10,000 sq. ft./lot)	0.47	0.62	0.67
R1-7 (7,000 sq. ft./lot)	0.51	0.64	0.70
Townhouses (R-2, R-4)	0.63	0.74	0.78
Apartments & Condominiums (R-3, R-5)	0.76	0.83	0.87
Specific Surface Type Values			
Paved streets, parking lots (concrete or asphalt), roofs, & driveways, etc.	0.95		
Lawns, golf courses, & parks (grassed areas)	0.33	0.56	0.66
Undisturbed natural desert or desert landscaping (no impervious weed barrier)	0.31	0.48	0.56
Desert landscaping (with impervious weed barrier)	0.83	0.83	0.83
Mountain terrain – slopes greater than 10%	0.70	0.70	0.70
Agricultural areas (flood-irrigated fields)	0.20	0.20	0.20

FIGURE 4-5. RUNOFF COEFFICIENTS FOR USE WITH RATIONAL METHOD

D. The Army Corps of Engineer's HEC-1 Computer Model

HEC-1 procedures are applicable for any watershed area over 160 acres and up to 100 square miles in size. HEC-1 is required for analyzing drainage areas over 160 acres in size. **HEC-HMS is not an acceptable substitute for HEC-1**. Minimum required submittals when using HEC-1 are:

- A printout of the input data
- A schematic (routing) diagram of the stream network
- The runoff summary output table
- Electronic input file(s), on CD or floppy
- Supporting Documentation and Source Material for parameter selection

1. Precipitation

Precipitation values for HEC-1 modeling shall be determined using the Flood Control Manual, specifically PD and JD records for point rainfall and area reduction factors. Capital Projects shall use the ADOT manual and methodology when specified. Precipitation values are to be obtained from the Isopluvial maps for the specific frequency desired (see Appendix 4-D).

2. Infiltration

Infiltration or soil losses will be determined using Green and Ampt (G&A) procedures per FCDMC Hydrology Manual. Use the most recent published SCS soil survey maps of the area to determine the hydrologic soil group or surface soil texture for the G&A procedures. Use USDA Natural Resources Conservation Services (previously the Soil Conservation Services) maps, Soil Survey of Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, or the Soil Survey of Eastern Maricopa and Northern Pinal Counties, Arizona; depending on what part of the city you are located.

3. Runoff Curve Numbers

Where detailed mapping is not available from the SCS or other sources, the use of curve numbers is acceptable. When using runoff curve numbers (ROCN) within Scottsdale:

1. Assume poor hydrologic condition and desert shrub cover type for natural undisturbed desert conditions in Figure 4-6.
2. For lawns, golf courses, and other grassed open space areas, assume good condition in Figure 4-7 to determine the ROCN, then adjust the ROCN to antecedent moisture condition III (use Figure 4-8).
3. For developed conditions, increase the percent impervious on the LS card without changing the ROCN (except in the case of grassed areas, in which the curve number should be adjusted up according to the above). Use the actual or estimated percent impervious; a minimum of 85 percent for commercial and 72 percent industrial.

RUNOFF CURVE NUMBERS FOR ARID & SEMIARID RANGELANDS[1]

Cover Type and Hydrologic Condition	Hydrologic Condition[2]	Curve Numbers for Hydrologic Soil Group			
		A[3]	B	C	D
Herbaceous: mixture of grass, weeds, and low-growing brush, with brush the minor element	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen: mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper: pinyon, juniper, or both; grass understory	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub: major plants include saltbush, greasewood, creosote bush, blackbrush, bursage, Palo Verde, mesquite, and cactus	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

[1] Average Runoff Condition, and I_a = 0.2S.

[2] Poor: < 30% ground cover (litter, grass, and brush overstory)
Fair: 30 to 70% ground cover (not applicable in Scottsdale)
Good: >70% ground cover (not applicable in Scottsdale)

[3] Curve Numbers for Group A have been developed only for desert shrub

FIGURE 4-6. RUNOFF CURVE NUMBERS FOR ARID & SEMIARID RANGELANDS

FULLY DEVELOPED URBAN AREAS WITH ESTABLISHED VEGETATION					
Cover Type and Hydrologic Condition	**Avg. % Imp. Area[2]**	**Curve Numbers for Hydrologic Soil Group**			
		A	**B**	**C**	**D**
Open Space (lawns, parks, golf courses, cemeteries, etc.)[3]					
Poor condition (grass cover less than 50%)		68	79	86	89
Fair condition (grass cover 50-75%)		49	69	79	84
Good condition (grass cover greater than 75%)		39	61	74	80
Impervious Areas					
Paved parking lots, roads, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets & Roads					
Paved; curbs and storm sewer (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of way)		83	89	92	93
Gravel (including right-of way)		76	85	89	91
Dirt (including right-of way)		72	82	87	89
Western Desert Urban Areas					
Natural desert landscaping (pervious areas only)4		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1 to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban Districts					
Commercial and business	85	Not Applicable in Scottsdale			
Industrial	85				
Townhouse, duplexes	85				
Multi-family	85				
DEVELOPING URBAN AREAS					
Cover Type and Hydrologic Condition	**Avg. % Imp. Area[2]**	**Curve Numbers for Hydrologic Soil Group**			
		A	**B**	**C**	**D**
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94

1 Average Runoff Condition, and I_a = 0.2S.

2 The average percent impervious area shown was used to develop the composite CNs. Other assumptions are: Impervious areas are directly connected to the drainage system; impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition (not applicable in Scottsdale).

3 CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

4 Composite CNs for natural desert landscaping should be computed based on the impervious area percentage (CN=98) and the pervious area CN. The pervious area CNs are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CNs to use for the design of temporary measures during grading and construction should be computed based on the degree of development (impervious area percentage) and the CNs for the newly graded pervious areas.

FIGURE 4-7. RUNOFF CURVE NUMBERS FOR URBAN AREAS[1]

RUNOFF CURVE NUMBERS (CN) FOR ANTECEDENT MOISTURE CONDITIONS I, II, & III						
Condition II	Condition I	Condition III		Condition II	Condition I	Condition III
100	100	100		61	41	79
99	97	100		60	40	78
98	94	99		59	39	78
97	91	99		58	38	77
96	89	99		57	37	76
95	87	98		56	36	75
94	85	98		55	35	75
93	83	98		54	34	73
92	81	97		53	33	72
91	81	97		52	32	71
90	78	96		51	31	70
89	76	96		50	31	70
88	75	95		49	30	69
87	73	95		48	29	68
86	72	94		47	28	67
85	70	94		46	27	66
84	68	93		45	26	65
83	67	93		44	25	64
82	66	92		43	25	63
81	64	92		42	24	62
80	63	91		41	23	61
79	62	91		40	22	60
78	60	90		39	21	59
77	59	89		38	21	58
76	58	89		37	20	57
75	57	88		36	19	56
74	55	88		35	18	55
73	54	87		34	18	54
72	53	87		33	17	53
71	52	86		32	16	52
70	51	86		31	16	51
69	50	85		30	15	50
68	48	84				
67	47	84		25	12	43
66	46	83		20	9	37
65	45	82		15	6	30
64	44	82		10	4	22
63	43	81		5	2	13
62	42	80		0	0	0

FIGURE 4-8. RUNOFF CURVE NUMBERS FOR ANTECEDENT MOISTURE CONDITIONS I, II, AND III

4. Hydrograph Generation

Small basin or sub-watershed hydrographs can be generated using the SCS dimensionless unit hydrograph procedure or kinematic wave method as described in the HEC-1 Users Manual. Computation time intervals should generally range from 5 minutes to 1 minute.

5. Time Of Concentration ("Tc")

Use the estimated time of travel, from the most hydraulically remote part of the watershed to the concentration point. The procedures from Chapter 3 of SCS's TR-55 are recommended for obtaining **Tc**.

CAUTION: For the SCS method, remember TLAG on the UD input card is 0.6(**Tc**), not **Tc**.

6. Channel Routing

Channel routing should use the Normal Depth (Modified Puls), eight point routing procedure as described in the HEC-1 Users Manual.

CAUTION: For the 1990 version of the HEC-1 program do not use the kinematic wave method with the multi-ratio JR cards because the hydrographs do not combine properly. For the 1988 version, do not use JD cards with the Green-Ampt method, as errors will result. HEC-1 versions prior to the 1988 version will not be accepted.

E. Pre- Versus Post-Development Discharge Analysis Procedures

The following HEC-1 analysis procedures must be used when it is necessary to establish a comparison of pre-development to post-development discharge (runoff) conditions.

1. The HEC-1 modeling procedures described in Section 4.706 must be followed.
2. Reflect fully developed conditions by:
   b. Increasing the percent impervious on the LS card to reflect the amount of impervious surfaces that will exist under fully developed conditions
   c. Recalculate the time of concentration (**Tc**) based on the proposed drainage system, after full development. Normally there should be a reduction in **Tc** after development
   d. The existing condition model must be sub-divided, as necessary, to create concentration points which will match the sub-watershed areas above each proposed storage facility under fully developed conditions
   e. Each separate storage facility proposed must be modeled as it will physically exist under fully developed conditions with appropriate routing and combining operations through each basin and through the entire watershed. The modeling of storage capacity provided, as one hypothetical reservoir at the outlet with all the upstream storage arbitrarily combined at this one location, is not acceptable
   f. As a minimum, the 2, 10 and 100-year frequency events shall be analyzed
   g. Comparison of discharge values for existing and post development conditions must be made at concentration points just downstream from each proposed storage facility; other critical locations such as road crossings; and at points where flows exit the proposed development.

4.707 CALCULATION OF RUNOFF VOLUMES

The only accepted method for determining the required stormwater storage volume is the standard formula described below. HEC-1 modeling can be used for storage basin design and analysis or if a pre-versus post volume difference is needed. City ordinance requires on-site storage of runoff from the 100-year 2-hour frequency event.

A. Standard Formula for Runoff Volumes

$$Vr = (P/12)\ AC$$

Vr = *Required storage volume in acre-feet.*

P = *Precipitation amount = 2.82 inches. The average depth of the 100-year 2-hour duration rainfall, applies citywide.*

A = *Area in acres; the developed portion of the entire site in acres, to the centerline of adjacent streets, on which any man made change is planned, including, but not limited to: construction, excavation, filling, grading, paving, or mining.*

C = *Runoff coefficient; Rational Method values from Figure 4.9-3, either composite or weighted can be used.*

R = *R-Value*

B. HEC-1 Computer Modeling

The HEC-1 model, or similar computer program, is not to be used to determine the ordinance required 100-year 2-hour stormwater storage runoff volumes. The HEC-1 program may be used for the purpose of analyzing storage basin routing; or, for pre versus post analysis (a six-hour storm, and procedures described in Sections 4.905 E and F must be used). Use modified Puls level pool routing option in HEC-1 for hydrograph routing through storage basins and lakes. For permanent lakes, assume no available storage below the normal water surface elevation.

CAUTION: Do not use the built-in orifice equation in the HEC-1 model because errors can result. It is necessary to build a stage discharge table and input to the model.

GRADING & DRAINAGE PLANS 4.800

Chapter 1 should be reviewed for basic plan requirements that apply to all construction plans prepared for submission to the city. The following is a listing of informational and formatting requirements for the preparation of grading and drainage plans. Most grading and drainage related design requirements are contained in other portions of this chapter. Additionally, site layout and other design related requirements that may impact the overall design of grading and drainage related improvements for a project are described in other chapters of this manual.

GRADING AND DRAINAGE PLAN REQUIREMENTS 4.801

The following requirements apply to all grading and drainage plans prepared for submission to the city of Scottsdale.

1. The plan must encompass the entire development or site and a minimum of 50 feet outside. The plan must show and clearly label all existing utilities and improvements, topographic features and show topography within the site and 50 feet outside as discussed above.
2. For most projects, the plan scale should be 1" = 40'. For projects that will utilize a high level of detail for grading improvements, a scale of 1" = 30', 1" = 20', or 1"=10' may be used. The use of a scale smaller than 1" = 40' shall be approved by plan review staff prior to the first submittal of final plans. In all cases plans shall be clearly readable in the opinion of final plan review staff for a 50% reduced copy of the plans.

3. Existing topography shall be in the form of 1-foot contours. The 5-foot contour line shall be darkened and/or utilize a different line type than the remaining 1-foot contour lines for readability of the plan.
4. Spot elevations may be used in lieu of 1-foot contours for sites that do not have enough relief for the use of 1-foot contours. The use of spot elevations in lieu of 1-foot contours shall be approved by plan review staff prior to the first submittal of final plans.
5. For adjacent properties, the plan must show property lines and label assessor's parcel numbers. The plan must also provide city case and plan check numbers for adjacent development that has occurred in the last 5 years.
6. The plan must show and clearly label all existing and proposed easements or rights-of-way. For existing easement or right of ways, the Maricopa County Recorder's number should be provided. For easements, the easement type should be labeled. A partial listing of easements that may need to be shown is as follows: drainage, water, sewer, emergency and service vehicle access, vista corridor, sight visibility, public utility, sidewalk, and natural area open space. Existing street right of ways and street improvements shall be dimensioned as per MAG Standard Detail 112.
7. For proposed easements, the easement type should be labeled and the limits of the easement clearly delineated on the plan. For easements or portions of easements with a constant width, the width of the easement should be dimensioned.
8. If an adjacent project is planned or approved but not constructed, an outline of the proposed improvements and, if applicable, proposed property lines shall be shown on the plan.
9. The plan must show all proposed and existing property lines within the site.
10. The plans must show the 100-year flow rate for all washes or swales entering and exiting the boundary of the site and must also provide intermediate values of the 100-year flow rate within the site at least one time per sheet per wash, at confluences, and at points of interest such as culverts, storm drains, utility crossings, channel improvements, etc. The 100-year flow rate should be shown with a directional arrow in the following format: Q_{100} = xx cfs
11. The limits of 100-year floodplains should be delineated and labeled on the plan for all plans containing washes with 100-year flow rates of 50 cfs or greater.
12. For washes with 100-year flow rates of 500 cfs or greater, 100-year water surface elevations within the limits of 100-year floodplains should be shown and labeled on the plans.
13. Existing walls should be shown and labeled on the plans with top of wall elevations provided.
14. For proposed site, privacy, or retaining walls, the top and base of wall elevations should be provided on the plans. Elevations should be provided at ends, changes in elevation, or as needed to provide a reasonable level of definition of the elevations of the walls.
15. For developments with detention basins, the basin should be clearly labeled and the volume required and volume provided for the basin(s) be shown on the basin in the format VR = XXX ft^3 for volume required and VP = XXX ft^3 for volume provided.
16. A legend should be provided for all line types, symbols, and abbreviations used on the plan for both existing and proposed conditions.
17. Substantial cut and fill areas should be labeled with a directional arrow with the slope expressed as horizontal to vertical in the format H:V.
18. For culverts and storm drainage, the location of the culvert and storm drain should be shown on the plans with number, material and, size of pipes and upstream and downstream invert elevation labels. Culverts and storm drains should provide a cross reference to the sheet containing the profile for the structure.

19. For plans where buildings are proposed, the outline of the building should be shown on the grading and drainage plan.
20. For plans where habitable structures are proposed, the lowest finish floor elevation should be provided within the outline of the building. Scottsdale requires that lowest finish floor elevations for habitable structures be provided based on city of Scottsdale (NAVD 88) datum for certification purposes. To accomplish this, the lowest finish floor elevations shall be provided to nearest hundredth of a foot in the format LF_{88} = X,XXX.XX. If plan datum is not based on NAVD 88 datum, the lowest floor elevation based on plan datum may also be provided.

ADDITIONAL REQUIREMENTS BY PLAN TYPE 4.802

The following requirements are in addition to the above requirements depending on the type of plan or development. Some requirements may apply to other plan types depending on the nature of the project and improvements.

A. Commercial and Multi-Family

1. The location, orientation, and an outline of refuse enclosures, including approach slabs, shall be clearly shown on the plans.
2. Details of driveways, conforming to COS standard details, must be provided on the plans. In addition to the information contained in the city standard details for driveways, existing gutter grades at tie in, longitudinal slopes, the location of grade breaks, sidewalk ramps, curb return radii, existing curb and asphalt removal and asphalt replacement, shall be provided.
3. Horizontal control for proposed buildings, drive aisles, parking space dimensions, and any other substantial improvements should be provided on either the grading and drainage plan or separate plan sheets.
4. High and low points for driveway paving should be labeled with elevations.
5. Building setback lines should be shown and clearly labeled on the plan.
6. Traffic and parking striping should be shown on the plans.

B. Residential Subdivisions

1. Provide lot numbers.
2. Label tract names and street names from the final plat.
3. Dimension and label street and tract or right of way widths and show street centerline with stationing from paving plans.
4. Provide longitudinal and cross slope for streets.
5. Provide 100-year flow rates at curb cuts and catch basins.
6. For small washes or swales through lots on custom residential subdivisions, the flow path should be shown on the plans.
7. Label high and low points within streets with elevation.
8. Show building setback lines for production subdivisions
9. Provide top of curb elevations at the intersection of lot lines with the tract or right of way lines.

C. Custom Single Family Residential

Requirements for single-family development in the city can be found at www.scottsdaleaz.gov/bldgresources/SFRProcess.asp or by contacting Plan Review at 480-312-7080.

4.900 PRELIMINARY GRADING PERMITS

The grading and drainage related aspects of the project must be approvable in order to be considered for a preliminary grading permit. Specific requirements are:

1. The second plan review of the improvement plans must be completed prior to application for a preliminary permit.
2. All substantial grading and drainage related issues associated with a project have been resolved to the satisfaction of the engineering reviewer.
3. The project owner must submit a letter to the city requesting the preliminary permit, acknowledging that the city will not be responsible for subsequent changes to the project, and an explicit commitment to bring the project into compliance with the final approved plans.
4. A preliminary grading permit for a subdivision requires City Council approval of the final plat for the project. This requirement may be waived if approval is obtained from the Planning and Development Services General Manager. Preliminary grading permits may be issued prior to staff's approval of a Map of Dedication (MOD) for projects with an MOD.
5. A Native Plant Permit must be issued prior to the issuance of a preliminary grading permit. The Native Plant Permit number shall be placed on the improvement plans submitted for the preliminary grading permit.
6. A Haul Route Permit must be obtained, if applicable, prior to issuance of the preliminary grading permit.
7. The application for a Stormwater Storage Waiver must be approved, if applicable.
8. The completed No Conflict signature box must be placed on the cover sheet, signed and dated, and all applicable No Conflict letters submitted.
9. A copy of the AZPDES Notice of Intent (NOI) must be provided, as applicable.
10. A completed Section 404 Certification form shall be provided; and if applicable, a copy of the permit from the US Army Corps of Engineers.
11. Any other project specific requirements necessary for the City to issue a final grading permit.

The submittal requirements for the preliminary grading permit application are:

- 3 full size sets of grading plans (24" x 36"),
- The permit request letter, and
- Any other necessary information listed in the requirements.

Review and approval by Engineering, Planning and Fire, as applicable, is required. The review for preliminary permit is an expedited review; as such, the applicant must pay expedited review fees based on the hourly rate. The decision to approve a preliminary grading permit is at the discretion of the engineering reviewer based on the requirements listed above and on the nature of the project in general. The expedited review rate must be paid even if the preliminary grading permit is not approved.

STOCKPILE PLANS

4.1000

Temporary on-site stockpiles may be used to temporarily store excess soil from construction operations for a development.

A Staff Approval for the stockpile must be obtained from Current Planning. The stockpile submittal consists of a request letter and a grading and drainage plan showing the stockpile. The stockpile submittal is logged into the One Stop Shop and given a separate plan check number.

A. Request Letter Requirements

The letter, written to Plan Review staff, signed by the applicant, will state the duration the stockpile is intended to remain in place and the method that will be used to control dust.

B. Stockpile Grading and Drainage Plan Requirements

1. Plans should be prepared in accordance with the general requirements for a grading and drainage plan.
2. A Native Plant Permit is required for the area to be used for stockpile, and must be issued prior to the issuance of the Stockpile Permit. See Chapter 10 for the process and requirements for obtaining a native plant permit. The Native Plant Permit number shall be placed on the Stockpile plans submitted for the preliminary grading permit.
3. The location of the stockpile must be shown in plan view. The stockpile may not be located on, or within, any public utility, easement, or right-of-way.
4. At least one cross-section through the stockpile shall be provided. The cross-section should show and label the sideslopes and the maximum height of the stockpile.
5. The total volume of the stockpile must be provided on the plan.
6. All NAOS areas shall be clearly defined and labeled.
7. Plans should address drainage runoff from the stockpile and upstream watersheds. This may be accomplished by various means, including stockpile location, design and grading of the stockpile, or by the use of temporary stormwater storage.

Drainage Report Outline

Title Page: Project Name; Location; Type of Drainage Report (Preliminary, Master Plan, Final, etc.); and Engineer's Seal, Signature, and Date.

Table of Contents: Engineer's Seal, Signature, and Date.

1. **Introduction**
   - Project Name, Location, Size, and Brief Description;
   - Type of Report (Preliminary, Master Plan, Final, etc.); and
   - Purpose and Objectives.
2. **Description of Existing Drainage Conditions and Characteristics**
   - On-site drainage:
   - Existing drainage network, patterns, and watershed and floodplain boundaries.
   - Off-site watershed:
   - Existing conditions and the drainage network entering and existing the project site.
   - Context relative to adjacent projects and improvements;
   - Flood Hazard Zones on the property, FIRM maps.
3. **Proposed Drainage Plan**
   - General description of proposed drainage system and components; including conveyance of off-site flows;
   - Future conditions; including development of adjacent properties;
   - Stormwater storage requirements:
     Volume required, volume provided, and basin locations.
   - Pre- and post-runoff characteristics at concentration points exiting the property;
   - Proposed drainage structures or special drainage facilities:
     Include design criteria and probable effect on the existing upstream and downstream drainage system.
   - Project Phasing:
     Improvements to be constructed with each phase, impact of phased construction, and required interim improvements. Development requirements must be met independently for each phase.
4. **Special Conditions**- Project Stipulations, 401 & 404 Permits, AZPDES.
5. **Data Analysis Methods**
   - Hydrologic procedures, parameter selection and assumptions.
   - Hydraulic procedures, methods, parameter selection and assumptions.
   - Stormwater storage calculation methods and assumptions.
6. **Conclusions**
   - Overall Project
   - Project Phasing
7. **Warning and Disclaimer of Liability**
   - Each drainage report must include a completed Warning and Disclaimer of Liability (see Appendix 4-A).
8. **References**

Appendices - Hydrologic and Hydraulic Data and Calculations, and a signed Warning and Disclaimer of Liability

Input Files - HEC-1, and HEC-2 or HEC-RAS, on Compact Disk (CD)k

Exhibits

- Vicinity Map
- Existing Conditions
- Topographic Map of Off-Site Watershed;
- Topographic Map of Existing On-site conditions with current 2-foot (minimum) contour mapping;
- Current aerial photo, 800 scale or larger, showing site in context.
- Proposed On-site Drainage Plan
- Scale appropriate to type of drainage report and size of the project.

Appendix 4-B

Master Drainage Plan Outline

The items on this list are required as part of the submittal of a Master Drainage Plan in addition to the requirements of Section 4.704.

Title Page: Project Name; Location; Type of Report (Master Plan); and Engineer's Seal, Signature, and Date.

Table of Contents: Engineer's Seal, Signature, and Date.

1. **Introduction**
   - Project Name, Location, and Size
   - Project Description, including scope of project
   - Vicinity Map
   - Purpose and Objectives
   - Special Conditions; include Project Stipulations, 401 & 404 Permits, AZPDES.

2. **Description of Existing On-Site Drainage Conditions and Characteristics**
   - 400 Scale Aerial Photograph, clearly identifying project location, 30" x 30"
   - Topographic Map, 100 scale, one foot contour interval, 24" x 36"
   - Show Q100 year peak discharge rates at key concentration points
   - Identify watershed boundaries
   - Delineate floodplain boundaries of washes with Q100 year peak discharge rates of 250 cfs or greater
   - Describe existing onsite drainage characteristics

3. **Description of Existing Off-Site Drainage Conditions and Characteristics**
   - 800 Scale Aerial photos, city 800 scale.
   - Topographic Map, two (2) foot contour interval, 24" x 36"
   - Show Q100 year peak discharge rates at key concentration points entering and exiting the project site
   - Describe existing drainage conditions and characteristics, including the drainage network entering and exiting the project site; the impact of planned development, and the potential impact of future development
   - Describe relation to existing Master Plans and adjacent drainage plans.
   - Depict Flood Hazard Zones on the property

4. **Proposed Master Drainage Plan**
   - 100 Scale proposed on-site drainage plan, one foot contour interval, 24" x 36"; include location and description of proposed drainage system, facilities, and components, including conveyance of off-site flows and probable effect on the existing upstream and downstream drainage system
   - Show and describe major drainage structures or special drainage facilities needed.
   - Site development plan, 24" x 36"
   - Show Q100 year peak discharge rates for pre- and post-development conditions at key concentration points
   - Describe ordinance stormwater requirements, volume required, volume provided, and location.
   - Project Phasing:
     - Improvements to be constructed with each phase, impact of phased construction, and required interim improvements. Development requirements must be met independently for each phase.

5. Data Analysis Methods

- Hydrologic procedures, parameter selection and assumptions.
- Hydraulic procedures, methods, parameter selection and assumptions.
- Stormwater storage calculation methods and assumptions.

6. APPENDIX

- Data and Calculations (as applicable)
- Peak flow calculations (Rational Method or HEC I printouts)
- Channel design calculations
- Culvert design calculations
- Floodplain calculations (Manning's or HEC 2 printouts)
- Storage volume calculations
- Retention/detention basin inflow outflow analysis and design calculations
- Street Capacity Calculations
- Curb Opening, Catch Basin Calculations
- Storm Drain Calculations
- Sediment and Scour Calculations
- Rip-Rap Sizing
- Erosion/ Sediment Control Plan
- Soils and or Geologic Analyses
- Basis for setting finished floor elevations:
  - In relation to designated floodplains or adjacent washes
  - In relation to natural or adjacent ground elevation if in a Special Flood Hazard Zone or not in floodplain

Warning and Disclaimer of Liability

The Drainage and Floodplain Regulations and Ordinances of the City of Scottsdale are intended to "minimize the occurrence of losses, hazards and conditions adversely affecting the public health, safety and general welfare which might result from flooding caused by the surface runoff of rainfall" (Scottsdale Revised Code §37-16).

As defined in S.R.C. §37-17, a flood plain or "*Special flood hazard* area means an area having flood and/or flood related erosion hazards as shown on a FHBM or FIRM as zone A, AO, A1-30, AE, A99, AH, or E, and those areas identified as such by the floodplain administrator, delineated in accordance with subsection 37-18(b) and adopted by the floodplain board." It is possible that a property could be inundated by greater frequency flood events or by a flood greater in magnitude than a 100-year flood. Additionally, much of the Scottsdale area is a dynamic flood area; that is, the floodplains may shift from one location to another, over time, due to natural processes.

WARNING AND DISCLAIMER OF LIABILITY PURSUANT TO S.R.C §37-22

"The degree of flood protection provided by the requirements in this article is considered reasonable for regulatory purposes and is based on scientific and engineering considerations. Floods larger than the base flood can and will occur on rare occasions. Floodwater heights may be increased by manmade or natural causes. This article (Chapter 37, Article II) shall not create liability on the part of the city, any officer or employee thereof, or the federal government for any flood damages that result from reliance on this article or any administrative decision lawfully made thereunder."

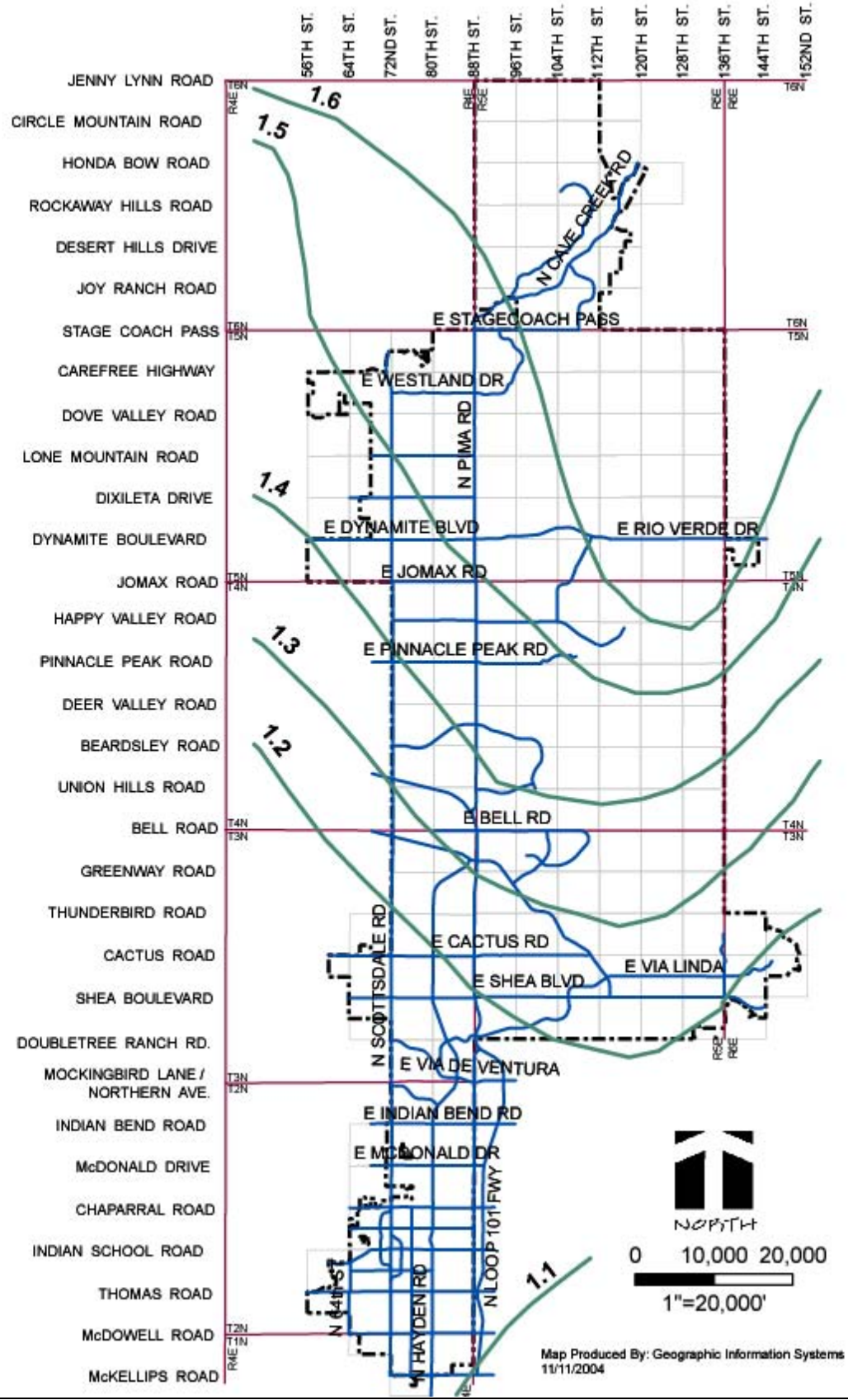
Compliance with Drainage and Floodplain Regulations and Ordinances does not insure complete protection from flooding. The Floodplain Regulations and Ordinances meet established local and federal standards for floodplain management, but neither this review nor the Regulations and Ordinances take into account such flood related problems as natural erosion, streambed meander or man-made obstructions and diversions, all of which may have an adverse affect in the event of a flood. You are advised to consult your own engineer or other expert regarding these considerations.

I have read and understand the above. If I am an agent for an owner I have made the owner aware of and explained this disclaimer.

_____	_____	_____
Plan Check No.	Owner or Agent	Date

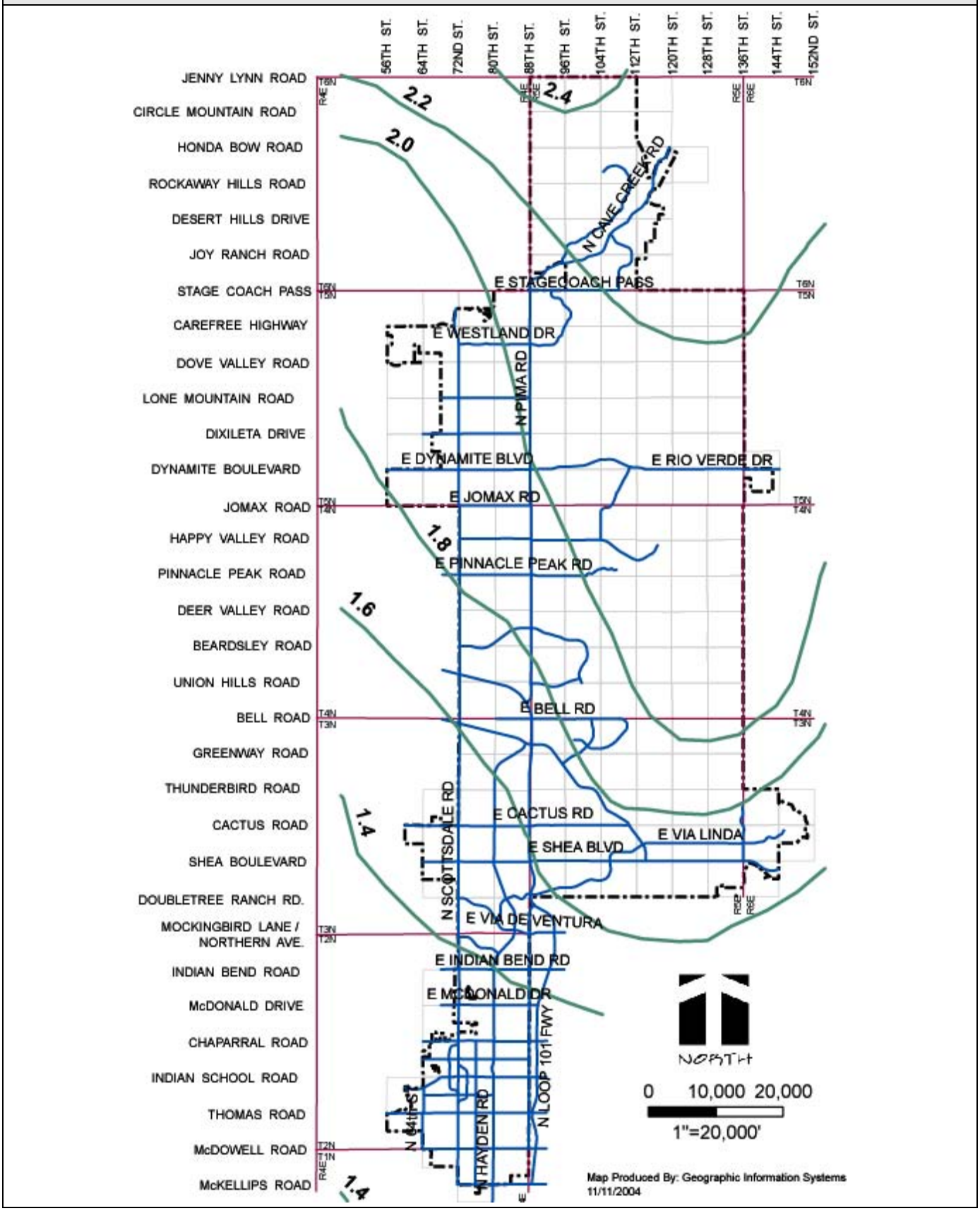
ISOPLUVIALS

2 Year 6 Hour Precipitation in Inches



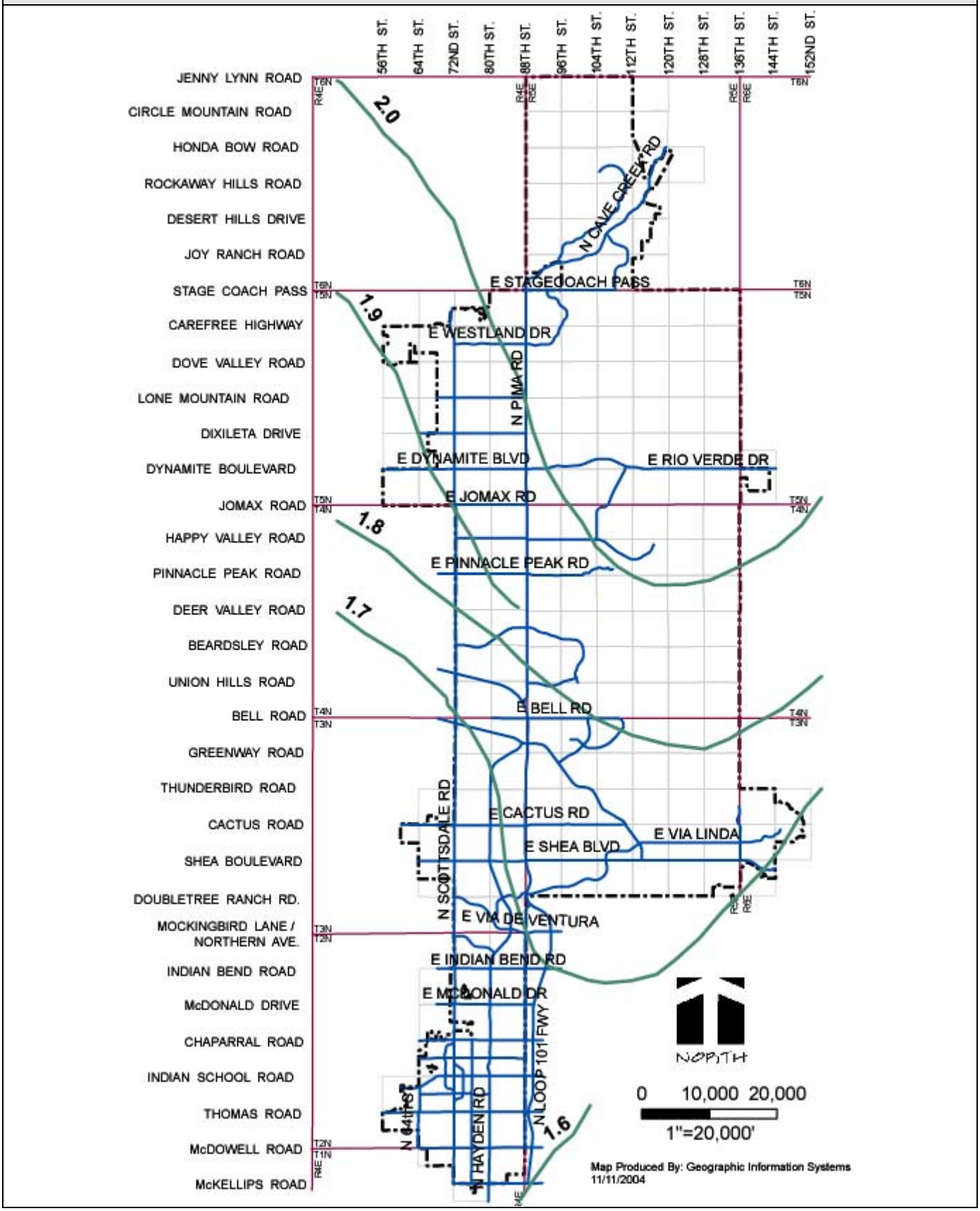
ISOPLUVIALS

2 Year 24 Hour Precipitation in Inches



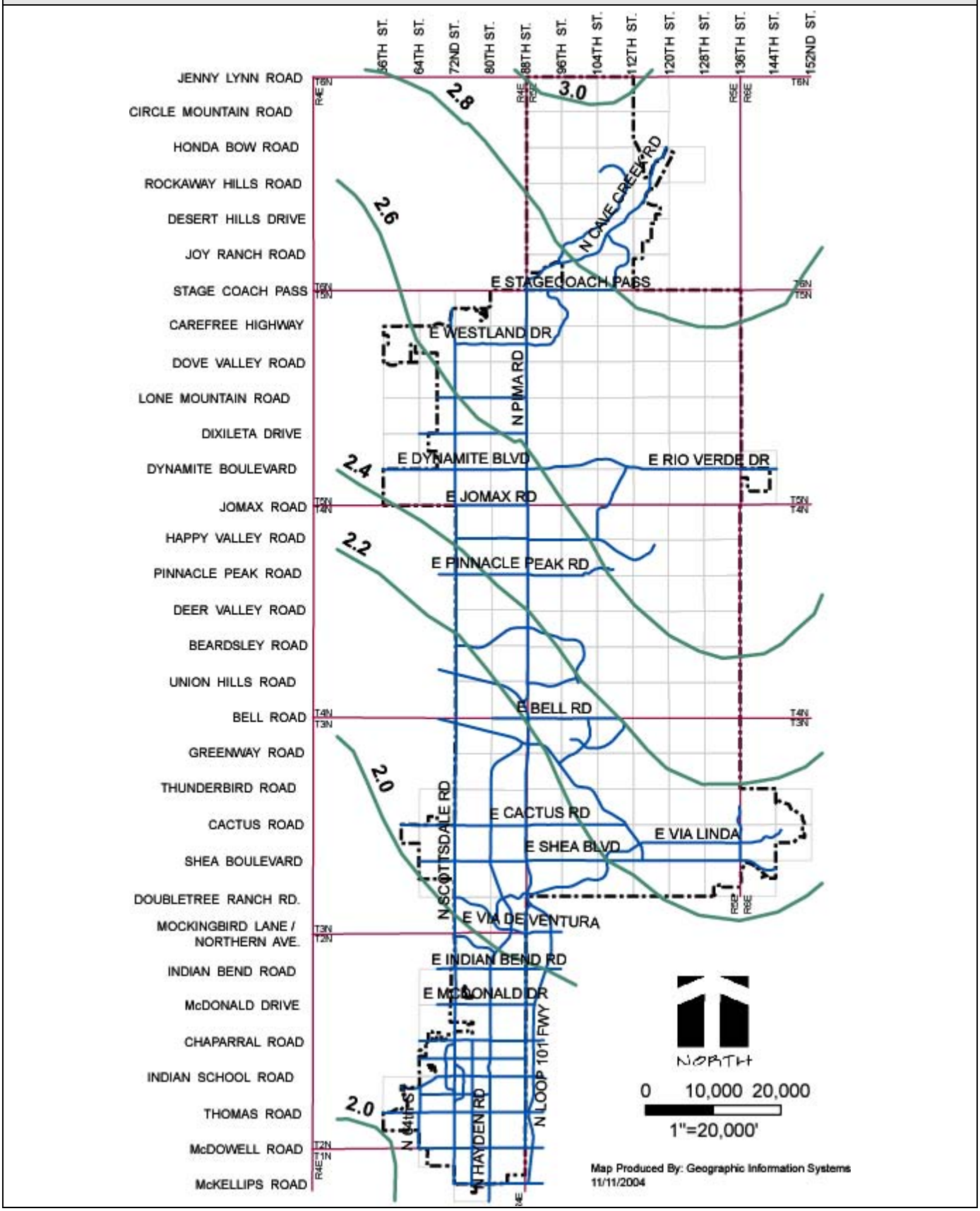
ISOPLUVIALS

5 Year 6 Hour Precipitation in Inches



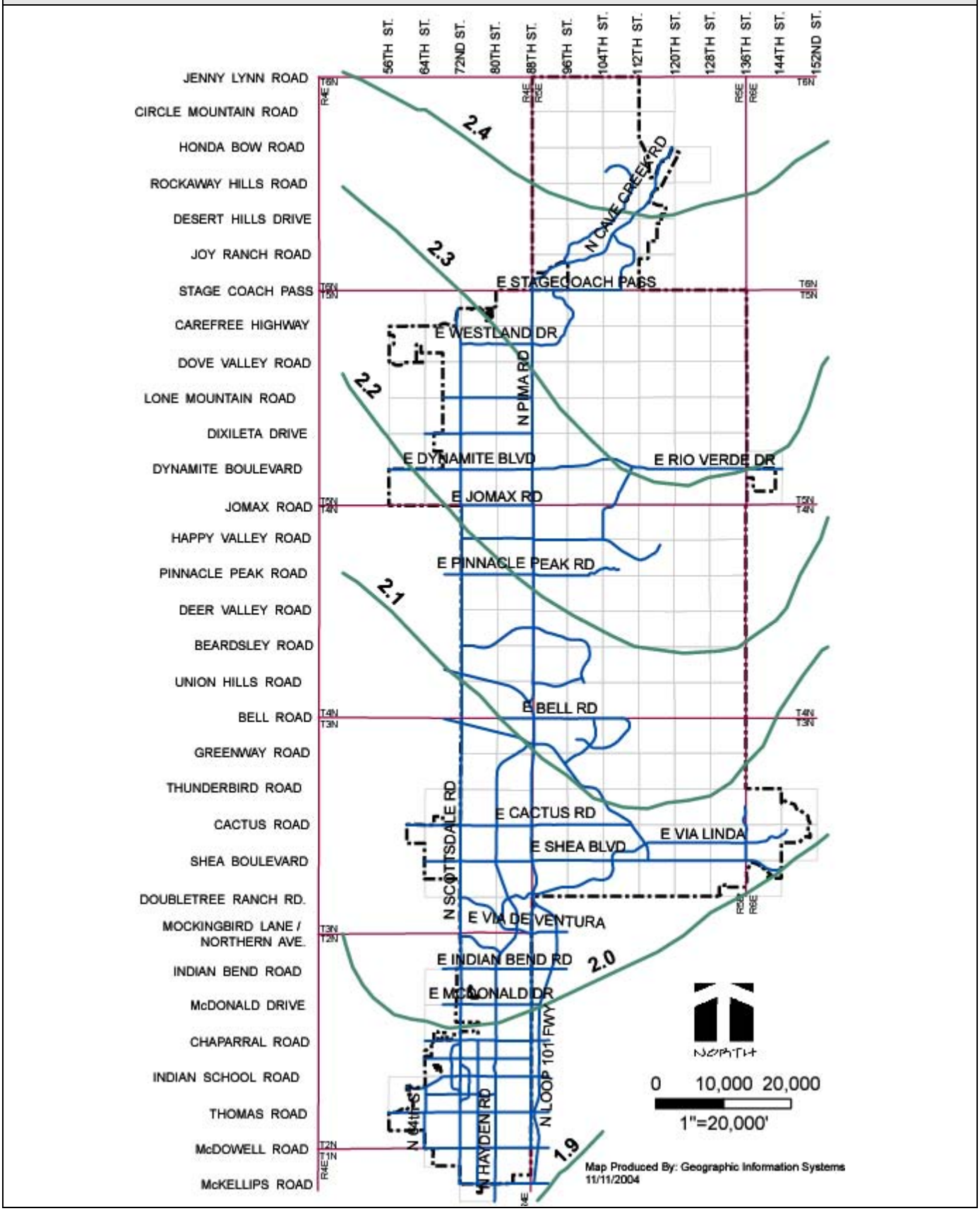
ISOPLUVIALS

5 Year 24 Hour Precipitation in Inches



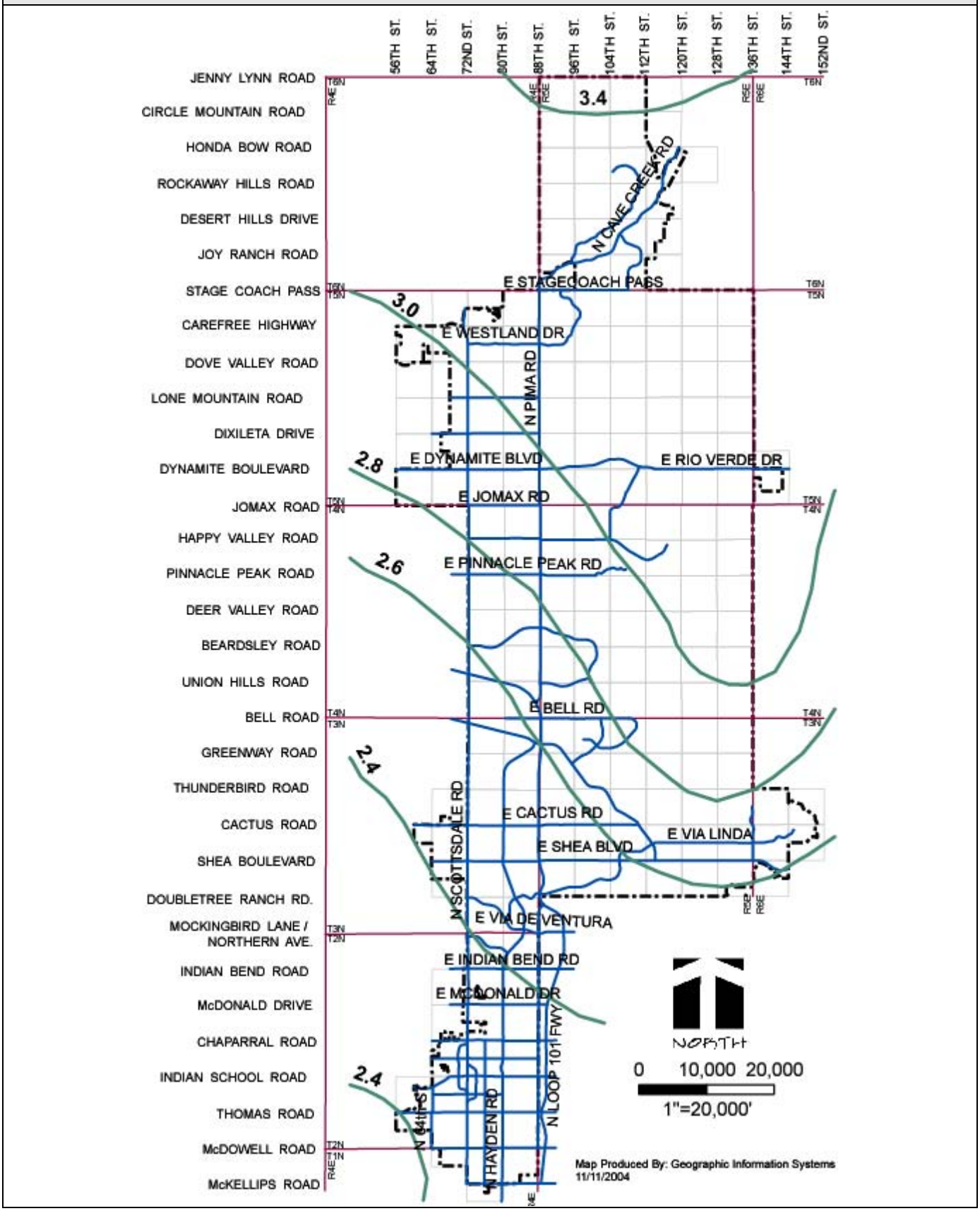
ISOPLUVIALS

10 Year 6 Hour Precipitation in Inches



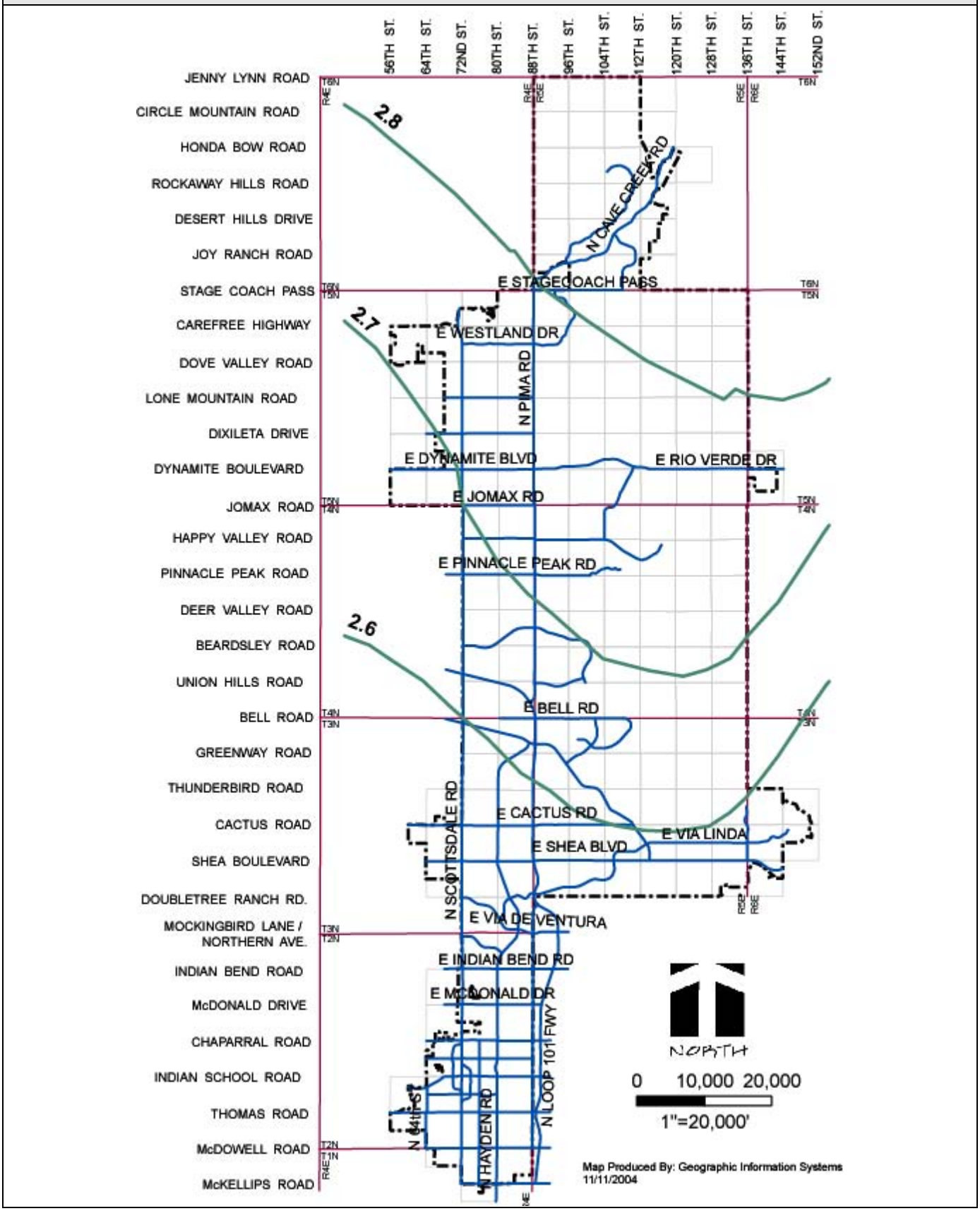
ISOPLUVIALS

10 Year 24 Hour Precipitation in Inches



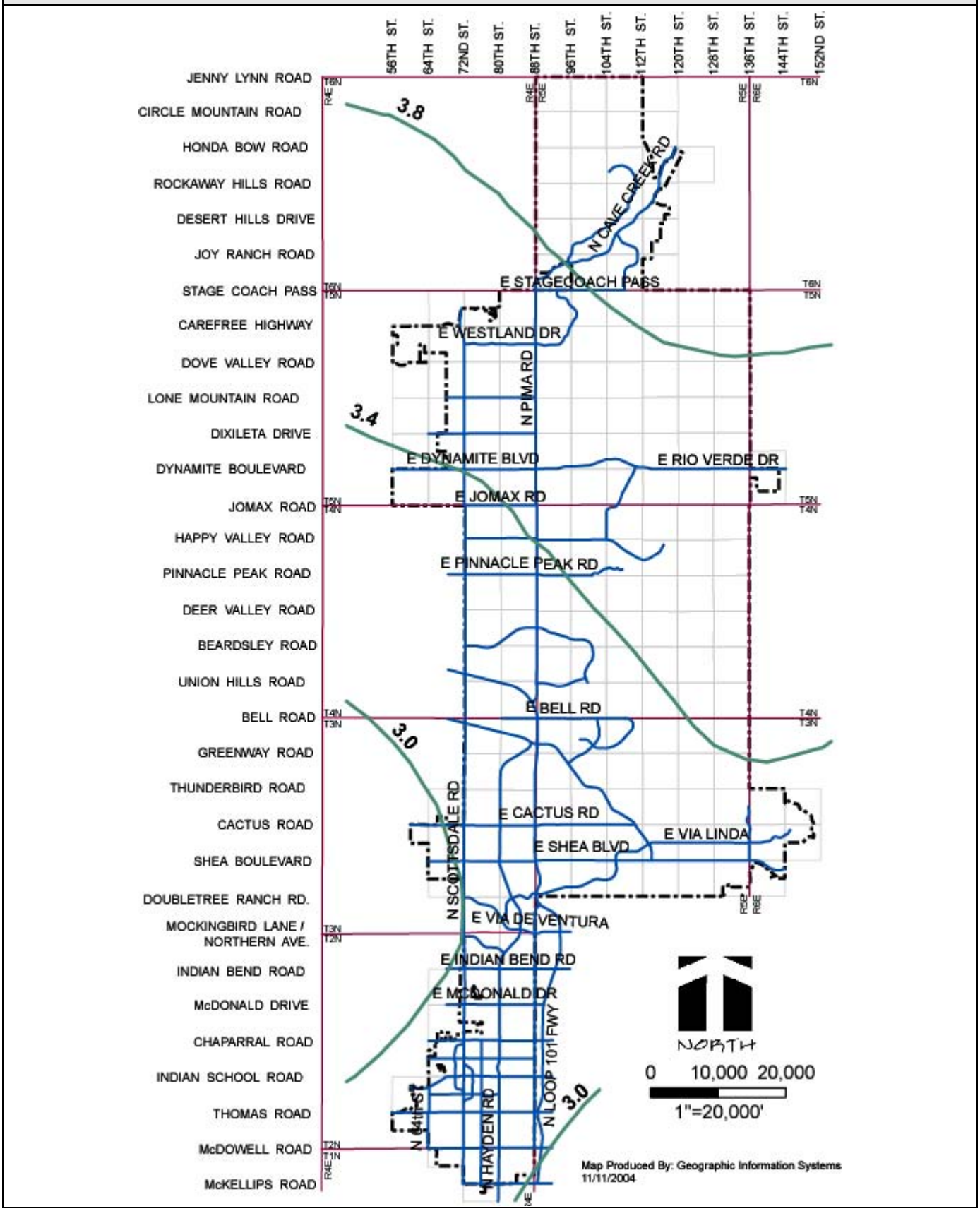
ISOPLUVIALS

25 Year 6 Hour Precipitation in Inches



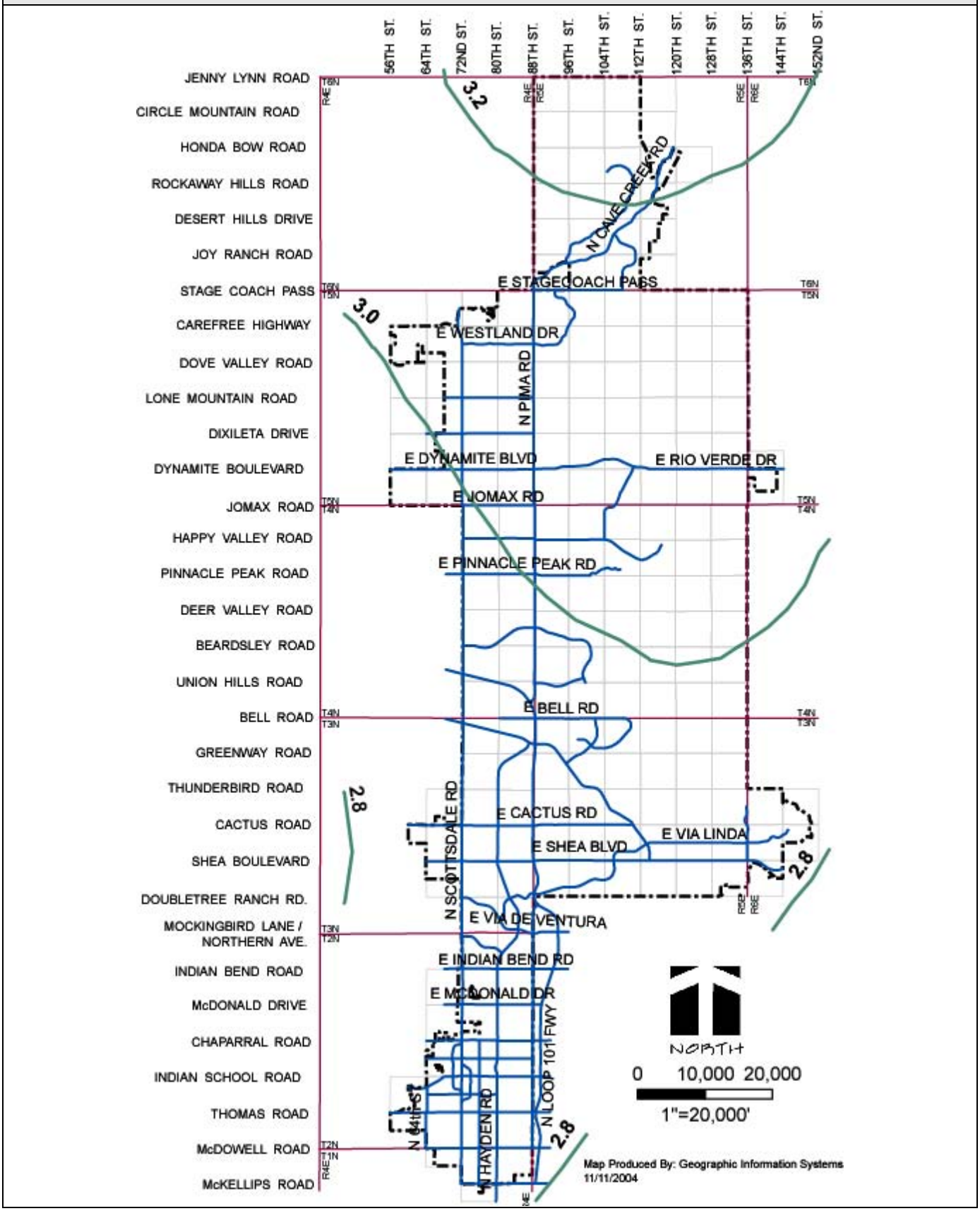
ISOPLUVIALS

25 Year 24 Hour Precipitation in Inches



ISOPLUVIALS

50 Year 6 Hour Precipitation in Inches



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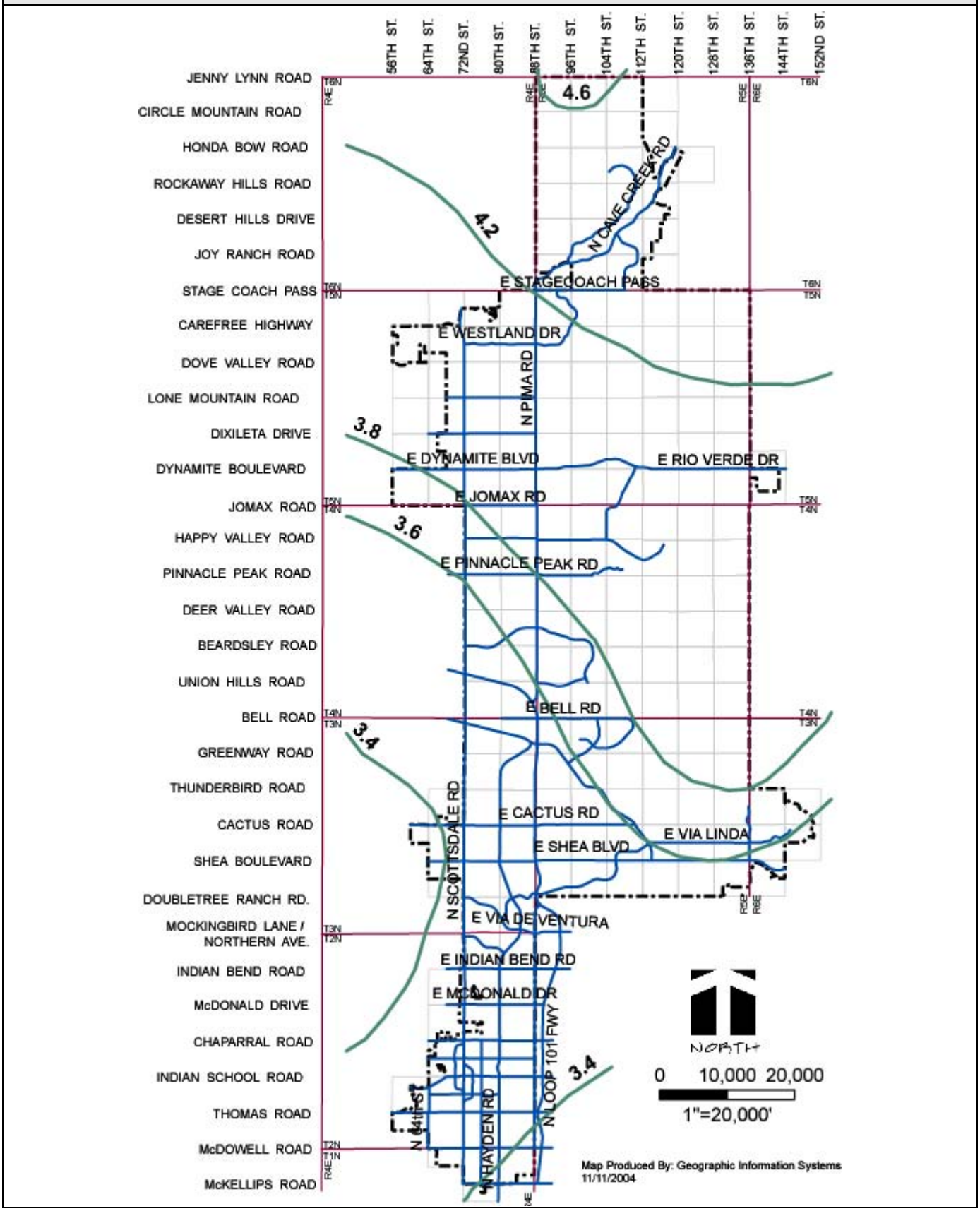
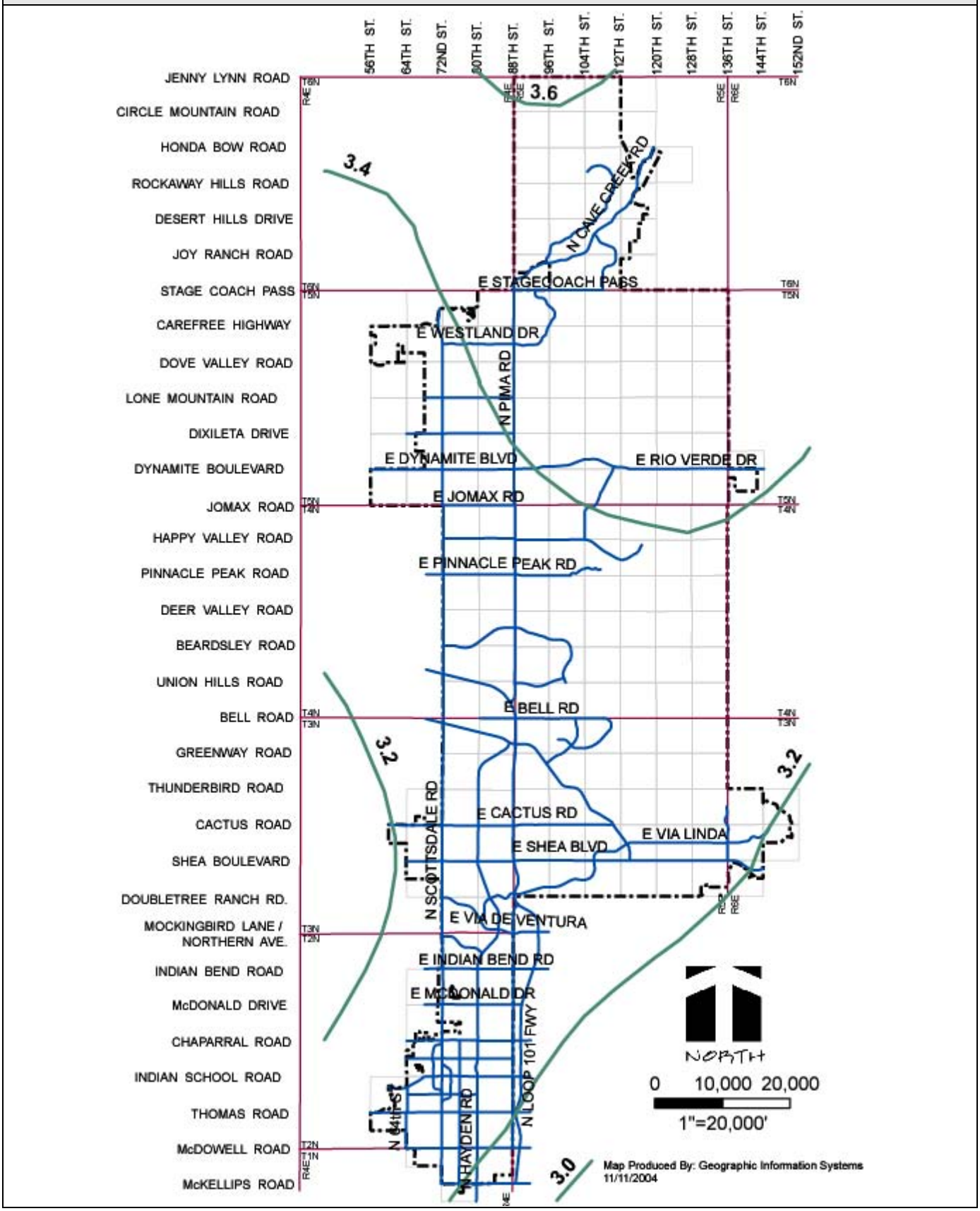
50 Year 24 Hour Precipitation in Inches



ISOPLUVIALS

100 Year 6 Hour Precipitation in Inches



ISOPLUVIALS

100 Year 24 Hour Precipitation in Inches